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THIS NUMBER COMPLETES VOLUME I
(Volume Title, Contents and Index will appear in following issue)

Vol. I DECEMBER 1930 No. 4

CHILD DEVELOPMENT

In this number there are reports of studies of sustained attention of children; of the development of motor control and of perception; of methods of training the left-handed child in use of right hand; studies of skeletal differentiation in youth, and of the negative phases of behavior in adolescence.

PUBLISHED QUARTERLY BY THE WILLIAMS & WILKINS COMPANY
MOUNT ROYAL AND GUILFORD AVENUES, BALTIMORE, U. S. A.

Made in United States of America

CHILD DEVELOPMENT

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CHILD DEVELOPMENT will be issued quarterly in March, June, September, and December of each year. The first number was published in March, 1930. The volumes will consist of about 400 pages. A volume will be issued within the year for which it is current.

The Subscription Price: $5.00 per volume in the United States and countries within the postal union: $5.50 in countries outside the postal union. Prices are net, postpaid.

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Publishers of Scientific Books and Periodicals

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Entered as second-class matter May 9, 1930, at the post office at Baltimore, Maryland, under the act of March 3, 1879

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Continuous Reaction as a Measure of Attention

MURIEL W. BROWN

THE PROBLEM

ABOUT six years ago, the present writer conducted a simple word learning experiment with a small group of children ranging in age from two and a half to four years. The task, in this instance, was to learn to recognize a number of printed words by associating them with toy objects which they represented.

At the close of the investigation we found marked individual differences in achievement. We also discovered that these individual differences did not correlate highly with intelligence as measured by the Stanford Binet I.Q. Some relatively dull youngsters with a certain placidity of temperament accomplished more, under the given learning conditions, than other, brighter, children who seemed unable to focus upon the problem for longer than a few seconds at a time. This tendency to distractibility was more marked with the younger subjects but appeared at all chronological age levels. We further noted that wherever this inattentive behavior appeared it had certain fairly well defined characteristics. Movements were mercurial,—particularly eye movements. There was marked diffuseness of energy output, with little evidence of control. Response to the test situation seemed to be, not integrated effort under the direction of a persistent idea, but rather, a series of fairly discrete reactions to an environmental kaleidoscope of stimulus patterns.

These observations raised a number of interesting questions in regard to the nature of attention. With this group of children, physical, intellectual and emotional factors seemed to be nicely integrated in the attentive states. What interfered with the coordinating of processes in the inattentive states? Is inability to control attention an organic, an emotional, or an intellectual defect? Does the power to attend develop gradually in small children with measurable increments between chronological age levels? Can attention be measured at all?

The following study is an attempt to explore a small corner of this very large and interesting field. It aims to deal with three aspects of the problem:

1. The measurement of attention
2. Acquisition of control of attention
3. Individual differences in attentivity

An experimental situation has been devised which rules out, as far as possible, known conditioning factors. Success depends primarily upon attention to the task,—a simple repeti-

tive process. The subjects are young children with no previous experience in this sort of thing. The set-up is a modification of the continuous reaction apparatus.

REVIEW OF THE LITERATURE

It has been somewhat difficult to relate this experiment to the older psychological work on attention, first, because it began as a frank exploration, planned to yield data which would suggest, rather than test, hypotheses; second, because of various confusions in terms. A review of the literature discloses so many definitions of attention that one is lead to wonder whether James could possibly have intended to include psychologists when he said "Every one knows what attention is."

The earlier writers (pre-18th century) regarded attention, in the main, as "an unanalyzable attribute of the soul—evidence of the independent activity of the mental principle." (3, p. 86). The majority of English empiricists (particularly Hume, Hartley, and Spencer) ignored it, perhaps, as James suggests, because it could not be treated as a pure product of experience. The Germans before Herbart "explicitly treated of it," but "either as a faculty or as a resultant." (35 p. 402). The literature of the late 19th century bristles with theories which Baldwin (3), p. 86) classifes as:

1. The affective.
   "Attention is an intellectual monoideism accompanied by spontaneous or artificial adaptation of the individual." There are two kinds, spontaneous and voluntary. Spontaneous attention is the rudimentary form and is the outcome of the natural impulses and desires; its essential elements are the motor processes. Voluntary attention does not differ in kind, but is later in the order of development, and "depends upon the emotions or impulses acquired by education." (72, p. 6.)
2. The "psychical energy" and "original activity" theories, (Lotz, Wundt, Stumpf, Ward, Ladd, etc.).
   Attention is defined in terms of degrees of consciousness. "We are, at the moment more conscious of some objects than of others, and it is the objects of which we are most conscious to which we are said to attend, or which are said to be 'clear'." (42, p. 597.)
3. The conative and motor theories, (Bain, Lange, Munsterberg, Stout, Baldwin).
   "That the ideational preparation itself is a consequence of muscular adjustment, so that the latter may be called the essence of the attention process throughout." (35, p. 444.)
4. The "intensity" and "reinforcement" theories, (Condillac, G. E. Muller, Bradley).
   These assume central sensory reinforcement of peripherally excited or centrally prepared sensations or ideas. (40, p. 444.)
5. The "inhibition" theory, (Ferrier, Alexander, etc.).
   "The physiological or psychological principle underlying every act of attention is inhibition in order to concentrate,—the shutting out of irrelevant matter in order to examine some central point." (2, p. 295.) "The changes which conscious contents undergo in one state of attention, and the motor phenomena which follow in its train admit of two interpretations, one of which accredits attention with functions both of reinforcement and inhibition, while the other attempts to explain all the facts in terms of inhibition alone." (40, p. 444.)

These brief quotations will suffice to give a bird's-eye view of the range of thought upon the subject under discussion. It is clear, as Külpe points out, that psychology has "confused in its idea of attention, three very different notions: that of a faculty, the operation of which produces certain changes in the mental life; that of an activity, the activity of remarking, noticing, observing,—always directed upon some definite content which is the occasion of its exercise; and that of a state in which we continue for a longer or a shorter time, unaffected by changes in the content of our consciousness." (41, p. 42).

"Contemporary psychologists," writes H. M. Johnson, "make use of a single term 'attention' to designate two variables, indifferently. One of these variables is the degree of consciousness, or the clearness of content; the other is the degree of the sensory and motor adjustment of the organism with respect to a particular stimulus." (37, p. 601). Since Woodrow (92), in 1916, argues at length for a "faculty" of attention, we may doubt whether the number of issues has been so far reduced as Johnson supposes. It seems to be true, however, that the concepts to which he refers have a general acceptance, and that as he further states, "two representative authors," Münsterberg and Dunlap are able to combine the two views in a theory of attention which specifically postulates that "the 'degree to which one is conscious,' or the 'clearness and vividness' of content, is determined by the degree of adjustment for reception and response; the latter being perhaps theoretically expressible as some function of the number of different pathways which combine in producing the appropriate response." (37, p. 604.) In other words, integration and attention,—consciousness, too, if you like,— are the same thing. It is surprising—and interesting,—to see how much of the old obscurity vanishes if the earlier theorists are translated into the language of modern scientific psychology.

The specific problems attacked in experimental studies of attention Baldwin (3) groups under the following heads: (1) Fluctuation of attention; (2) complication; (3) range of attention; (4) distraction of attention; (5) influence of attention on the estimation of time intervals; (6) reading time experiments; (7) attention and concomitant processes, physiological and psychological; and (8) the effects of attention.

The experimental work done between 1874 and 1908 has been admirably reviewed by L. R. Geissler (29), with special reference to method. He distinguishes between (1) the general means of inducing variations of attention, and (2) the special means employed for the measurement of these variations. Under (1) he divides procedures into the "single-task," or distraction method, and the "double-task," or the method of simultaneous activities. The "single-task" method was first used in 1874 by Wundt (93) and Obersteiner (60) who attempted to measure attention by means of reaction time using auditory, cutaneous and visual distractors. Distractors of many kinds have been used since then in a wide variety of experimental situations.

The "double-task" method was first employed by Loeb in 1886, to find out whether muscular activity could be used as a measure of mental activity. His work was later extended to include the correlation of the muscular strength of the hand with many different mental activities, such as visual and auditory perception, mental addition and multiplication, reading, writing and repeating poetry. In this connection the names of Münsterberg (56, 57, 58, 59) W. G. Smith (76), Drew (17), Binet (4), and Henri (34) should be mentioned, also those of McDougall (50, 51), and, particularly, Wirth (89). Experiments with both methods show that with different people the same distractions have different effects but the results are unreliable, depending largely upon the effectiveness of the distraction material as such. Distraction material may be ineffective, (1) because of lack of continuity, which permits the other task to rise, at moments, to the focus; (2) because of adaptation; (3) because of the improbability of getting distraction material which affects all normal subjects in the same way. (29, p. 492.)

The methods proposed for, or employed in, the measurement of attention, Geissler divides into six groups. "The first five may be classified as methods of expression. According to these, degrees of attention may express themselves in changes of, (1) peripheral vision; (2) muscular strength; (3) liminal and differential sensitivity; (4) reaction time; (5) accuracy of work. The sixth method may be likened to the method of impression. By a series of graded distractors, degrees of attention are to be induced in the observer, and he is afterwards to report which degree he experienced." (29, p. 492.)

Method 5 is essentially the method of the present experiment from the point of view of treatment of data, and, therefore, has a special interest here. This method "seeks to find an expression of the degree of attention in the quality and quantity of the work performed in a given time." Jodl (36, p. 84–85) says of it, "It is obvious that attention cannot be measured directly. However, its degrees may be determined indirectly by reference to its effects. These effects consist, in every task which does not have the character of an involuntary movement, in the avoidance of errors and mistakes and in the quickness of the execution." Stern (77, p. 84) also holds that "the quality and quantity of a task performed under normal conditions could be used as a measure of the attention energy."

Friedrich (26) first suggested a modification of this method in 1883 "It is tempting," he writes, "to fix definitely the somewhat unsettled concept of attention by making it proportional to the measure of precision, i.e., to the reciprocal value of the mean error, so that a small mean error corresponds to a high degree of attention, and conversely a large mean error to a low attention,—since the characteristic phase of attention consists rather in the large variations of the physiological times within the same experimental series." (26, p. 73.) He warns, however, that "only in cases of the simplest mental processes, which besides should be as homogeneous as possible, and

little subject to practice, may one assume that the mean error is mainly dependent upon the degree of attention. With more complex mental processes not only does practice play a considerable part in the fluctuations of the individual experiments, but, in certain cases, the cause of great variations may lie in the mental processes themselves." Oehrn (62) had 10 subjects count letters, look for certain letters, read proof, etc., and "made a wide application of the mean variation as the 'dynamometer of the attention'." (26) He found significant individual differences in variability and, particularly, differences in the kind and amount of attention given to the various tasks. Henri criticizes Oehrn's conclusions on the ground that factors like fatigue and practice were not eliminated, and certainly must have influenced the mean variations. Peters (63) found a close connection between the magnitude of the mean variation in determinations of liminal sensitivity and the degree of attention under which he had established the limen, "but assumed that" practice had a slight but distinct effect upon the results. Geissler suggests that the mean variation can best be used as a check upon conclusions drawn from other techniques.

Since 1908, experiments in the field of attention have touched upon all of the eight main problems outlined by Baldwin, tending of late years to center about either the clearness or the muscular adaptation hypothesis. Geissler (29) reports, on the strength of a study of fluctuations of attention to cutaneous stimuli, that "under good conditions, attention focused on liminal and subliminal sensations remains approximately constant for at least two or three minutes, and then gradually fades," (through adaptation). In 1909, he tested "the assumed parallelism of the expression methods" by correlating "the accuracy and quantity of work performed with the muscular rigidity or motor inhibition which is said to become the more pronounced the more attention is concentrated." (29, p. 503). He found "a very close parallelism . . . to exist between introspectively distinguishable variations of attention and corresponding differences in the precision of work performed at these levels under the condition that the estimation of degrees of attention was made in terms of clearness and that the work itself was not influenced by anything else but change of attention." (29, p. 529.)

Experiments for 1910 have to do particularly with Wirth's (89) method of measuring distribution of attention,—the method of liminal differences for brightness in different parts of the visual field under varying distributions of attention. Lipps (44) repeated Wirth's experiments and in general, confirmed his results, finding that the central and lower portions of the field were materially favored. The influence of attention in this situation is not clear, according to Pillsbury. Whipple (88) tested the mind-training theory proposed by Miss Aiken (1) and found but a negligible improvement in visual memory span for letters or objects, although his subjects were trained by 100–200 exposures. Dunlap (18), 1910, worked on the complication experiment and found three general methods of judging the posi-

tion of the moving pointer at the moment of a discrete stimulus, each of which produced a characteristic quality and quantity of error. Billings and Shepard (5), 1910, studied change of heart rate with attention and decided that the primary effect was in the respiration rate, which in turn affected the heart rate. There is frequently restricted breathing with sensory attention, they assert, which decreases the heart rate; with central attention there is little change in breathing, but a slight tendency to increase.

McComas (47), 1911, made an interesting study of types of attention, using various kinds of material in a field exposed by means of a tachistoscope. He found, in general, two types of attentional activity,—the broad and the narrow spanned. Subjects who were broad for visual were also broad for auditory span. Two other types were discovered—the alert, active, quickly controlled, and the sluggish, the former being broad-spanned. Intercorrelation of the data showed that the ability to concentrate and inhibit did not appear to be closely related to any other marked traits of attention. Prager (64) worked on the relation between defects of attention and control of association and found that disturbances of functions in the two fields went hand in hand. In a study of the effect of alcohol on attention, Busch found a narrowing of the field after 30 cc. of alcohol, (9).

The relation between attention and breathing was reexamined by Suter (79), 1912, who points out a difference between strain of attention and concentration. Feilgenhauer (22) in this same year worked on rate of change of attention with disparate stimuli (visual and auditory). He found "the smallest active step of attention to be 300 sigma, with little change of limits for different kinds of stimulation." He also discovered that the shifting of attention from stimulus to stimulus was smooth if stimuli were in the same realm, otherwise not. Rate of change, which, he thought, depended on the personality of the observers, could not be voluntarily accelerated, although it could be voluntarily slowed. Rate of change did not appear to be affected either by position of optical stimulation, direction of movement, or increase of stimulation.

Five papers in 1913 dealt with direction of attention. Flügel, (24, 25), used figures drawn in double perspective, and decided that direction of attention was the prime factor in reversal, and that local fatigue was not of importance. Billings (6) measured the duration of attention to supra liminal stimuli and found the maximum much smaller than the so-called attention wave. His 21 subjects gave a median of 1.69 seconds for duration of attention to a small object. Pillsbury (66) points out that if each recorded change in this case is thought of as two waves,—change, and awareness of change,—the resultant value corresponds approximately to Sherrington's refractory period of the reflex, and also to "a number of times in different mental operations that have been referred to the attention wave, or that probably have approximately the same conditions in the nervous systems." (66, p. 169.)

Martin, Paul and Welles (46), 1914,

tested the validity of the use of the sensory threshold as an index of the general state of the nervous system, comparing the threshold of the winking reflex, secured by faradic stimulation of a selected spot on the lower lid, with the sensory threshold for the same spot on the lid. Results showed that the reflex threshold tended to vary from its mean value less than the sensory threshold. The fact that "direction of divergence" was nearly always the same for the two types of limen was taken to mean that the attention, under the conditions of these experiments, manifested itself as a function of the condition of the higher brain centres. The authors conclude that the value of the sensory threshold depends on the state of the higher centres and that the threshold may justly be used as an indicator of such state. Woodrow (90), 1914, published a monograph on the measurement of attention which he followed with a paper in 1915 (91). He deals particularly with reaction to surfaces with sharp outlines, with and without the distraction of a warning signal occurring at irregular intervals before the stimulus. The conclusion seems to be that irregular intervals of this nature increase reaction time, (presumably because they do not coincide with the attention wave), but have less effect when the outline of the stimulus is clear.

In 1916, Woodrow (92) applied his method of distraction by means of irregular preparatory intervals to a study of the reactions of 12 subjects to touch, sound and light stimuli. His results led him to conclude that the mode of stimulus is a condition of attention. Marked individual differences were found but these, although differing in magnitude for the several cases, were found to be relatively the same for each type of stimulus. Woodrow concludes that "the degree of attention of any individual is conditioned in part by certain general conditions which remain constant while the type of mental process concerned is varied," and that "it is to these general conditions alone, are due the individual differences in degree of attention found in the present investigation," (92, p. 317). Curtis and Foster (12), also in 1916, studied the effect of changes in intensity and size upon the clearness of a Greek cross, and found that change in size has no effect. Clark (11), 1916, conducted an experiment in visual imagery and attention from which he concluded that (1) "changes in the clearness of the image correspond, to an appreciable extent, to the movements of the eyes; that ocular movement is more likely to occur in secondary attention than in primary or derived primary attention; and that characteristic ocular movements, and possibly general motor attitudes seem to be transferred from visual perception to visual imagery. (2 subjects.)

Morgan (54, 55), 1917, reëxamined the problem of attention during distraction and found that although 13 of his 21 subjects suffered a brief diminution in capacity at the beginning of distraction all but 4 finally gained. The measurement of incidental movements showed that increased capacity was the result of greatly increased force.

McQueen (52), 1917, found no correlation between the ability to distrib-

ute in one task and in another. He used the correlation method in the treatment of data obtained from 40 school children. He concludes, from his study that the capacity to distribute is specific, and adds that he found a low correlation between success in distribution and teachers' estimate of intelligence. The coefficient of correlation is highest for tests requiring concentration, and is negative for motor tests.

McComas (48), 1917, publishes an account of a new apparatus for recording continuous discrimination reactions, an apparatus very like the one used in connection with the present experiment. McComas' subjects reacted to four differently colored lights by pressing different keys. The lights appeared upon an exposure screen and the instant one colored light was extinguished another appeared. The order of appearance was miscellaneous and not repeated for 60 exposures. The rate of exposure was controlled by the subject and the records were taken off on a smoked drum. "A marker in circuit with the armature of the clock registered each correct reaction, and a marker in circuit with the reaction keys scored all reactions made."

Lobsein (45), 1919, gave Münsterberg's motormen's test to 12 children as a measure of attention and obtained a high correlation (r = .84) between intelligence and the test results. His criterion of intelligence was the ability to meet new demands, (made by tests of his own devising), quickly and accurately. He found, also, an inverse relation between extent and efficiency of attention.

Liddell (43), 1920, tested Ferree's theory that attention waves are due to adaptation of the part of the retina stimulated and got no relation between eye-movement and fluctuations of attention. Bowman (7), 1920, in a study of size vs. intensity as a determinant of attention found that "the left hand position is the more favored."

Fernberger (23), 1921, stresses the importance of range of visual apprehension as distinguished from range of attention. He points out that the statistical limen is a more reliable and more readily determined measure of the latter than any of the classical methods of getting span, since "in the range of apprehension one is interested in determining the number of objects the correct apprehension of which has a probability of 0.5." He finds that the observed relative frequencies of correct judgments follow a continuous function of ogive form, and that the individual limens in his experiment ranged from 6 to over 11 stimulus objects. (dots.)

Dallenbach (13, 14), 1922, compares position with intensity as a determinant of clearness and finds that "the left hand position and the position above have the attentional advantage, and that the most advantageous position of all is the position to the left and below the point of fixation.

McComas (49), 1922, used his continuous discrimination apparatus as a measure of attention in an experiment with 11 adult subjects. In the treatment of the results he considers particularly the relation between right and wrong reactions, assuming that "the

increase of the wrong reactions is an indication that the subject is relying less upon careful discrimination and choice of reactions and more upon chance, (which thus) becomes the prominent factor in the situation." (49, p. 7.) On the strength of this assumption, all of the wrong reactions were regarded as chance reactions, with the probability that 75 per cent of the chance reactions were wrong. This, according to McComas, left 25 per cent of chance reactions which were right. He, therefore, derived his scores by subtracting one-third of the number of wrong reactions from the total number of rights. During the past winter, the present writer has had many opportunities to note the great variety of circumstances which led, in the case of her five year old subjects, to the final pressing of the wrong key. In the light of the children's behavior, McComas' assumption of the nature of error seems somewhat unsatisfactory, and probably lessens the significance of his conclusions. His subjects reacted continuously for periods of ten minutes, and the scores show "marked differences in speed and accuracy of reaction and in the temporal variations in these factors." Reaction times were taken.

Dockeray (16), 1922, reports experiments with the sounder test, which he recommends highly as a test to determine individual differences in ability to overcome distraction. H. M. Wells, (87), 1922, notes that during a "choice" reaction there is a fall in resistance, indicated by the psychogalvanic reflex.

Griffiths and Gordon (31), 1924, go again into the question of the relation between Traube-Hering waves and attention rhythms and find a slight correspondence, which they attribute to the vasomotor changes accompanying attention and the motor responses associated rather than to the Traube-Hering rhythms themselves. Oehrn (62), 1924, repeated the classical "range of attention" experiment, using psychophysical procedure, and concluded that practice tended to increase the value of the threshold.

H. M. Johnson, (37), 1925, considers the "clearness" experiments of Cassel and Dallenbach (10), and shows by further statistical treatment of the original data that "the precision with which any particular value of clearness, Y, can be inferred from the corresponding reaction time, X, is but 3 per cent greater than the precision based on a mere guess from the average My—in other words" there is no proof here (as the authors claim) that the reaction time is determined chiefly, if not entirely, by the degree of adjustment for reception and response.

For a resumé of the work done between 1925 and 1928, the reader is referred to Dallenbach (15). Dallenbach classifies the studies published during these three years in four groups, as follows:

1. Those concerned with the definition and ultimate nature of attention.
2. Those dealing with some special aspect of the subject, such as range, fluctuation, etc.
3. Those that treat of attention in relation to some other phenomena.
4. Those that are technological.

Nothing reported under 1 is of special interest in connection with this paper

except possibly a bit of nursery school research (Bertrand) in which an attempt is made to differentiate between spontaneous and voluntary attention in 36 children ranging in age from two years two months to six years. The author of this investigation finds that the length of time his children attended to a game varied greatly for different days. He reports an age and sex difference in the duration of this type of attention, and also finds that the means vary on different days of the week and on the days following holidays. One suspects that the measurements in these situations were affected by a good many other factors besides attention however defined.

With respect to 2,—special aspects of attention,—Dallenbach finds a wide range of studies of varying interest and importance. There appears to be a marked tendency among experimenters to agree that "the question of range is not a proper one to ask regarding attention. *The attentive consciousness is an integrated whole;* and as such the range of attention is unity." It seems also to be agreed by most writers that so-called fluctuation of attention is a question of limen. Dallenbach and Johnson continue their debate on the problem of measurement, Dallenbach stressing again his thought that by a proper treatment of reaction times it may be possible to discover the relations existing between clearness and reaction. Sterzinger (78) reports the results of a study of distribution of attention. His subjects added continuously while listening to the reading of a short story. The author concludes that generalization from this type of experience is risky, since it is difficult to tell under such conditions whether one is dealing with simultaneous or with rapidly shifting attention.

Several papers during this period dealt with the relation of attention to other phenomena, Dallenbach's third classification. Dallenbach describes an "attentional learning board" devised by Roberts and Farnsworth. With this apparatus, the rapidity with which the problem is solved depends upon the subject's attention to details.

Under 4, we find some discussion of tests of attention. Sterzinger (78) points out that such test results are significant only in so far as they test special abilities.

A paper by Skawran (75), is interesting in that it makes a more theoretical attack upon the problem of attention, and contains the statement that "all volitional decisions (as in choice reactions) are to be attributed, in greater or less degree, to feelings and strain sensations."

Verwoerd (84) in 1928, published a paper on the testing of distribution of attention. His subjects reacted to the flashing of stimulus lights by pressing corresponding telegraph keys. He found large individual differences in general efficiency and evenness, but concluded that the two were not correlated. The nature of the set-up makes a detailed analysis of this relationship difficult if not impossible.

In 1929 we find several studies of some importance, a number of them coming from German laboratories. Kindler (39) investigates training of attention, using the Bourdon test for typing, adding, etc., and getting his subjects to report on introspections.

He concludes that training in certain situations is possible but that such training is influenced by a variety of conditioning factors.

Enke (21) studies the splitting of attention in relation to constitutional type, and finds that results are not influenced by differences in the ages of the subjects. He infers from this that age does not influence the constitutional type. With this investigation, Enke enters a fascinating field and one but little explored. Studies of this kind are quite likely, eventually, to give us a technique for diagnosing in young children incipient psychotic trends.

Wallon, in France (85) investigates the psycho-physical causes of inattention in children. The author avoids the use of the term attention as ambiguous but finds that "nearly all the causes leading to *in*attention are correlated with motor disorders."

Perhaps, after all, this negative approach gives us one of our best clues to the real nature of attention. The long attempt to subtract an attentive process from other mental processes has obviously failed. On the other hand all of the experimental work done, even those investigations based on the older hypotheses, seems to strengthen the major premise of modern scientific psychology—the concept of an integrated organism reacting to stimulation as a whole. One now finds the terms "attention," "dominant pattern" and "integration" all used in the literature with essentially the same meaning to describe this totality of response. We pick up the thread in our present study by making this our working definition.

ORGANIZATION OF THE EXPERIMENT

Re-statement of objectives

The general purpose of this investigation has already been stated: We aimed to experiment with the problem of measurement, to study the question of control, and to analyze certain individual differences in attention to a given stimulus—response situation. We defined attention as the integration of all relevant processes, physiological and psychological, in a total response pattern. Proceeding from this definition, we made the fundamental assumption that a measure of efficiency in performing a simple motor act is also a measure of attention.

Method of approach

The next step was to find a response situation in which learning, fatigue and distraction were essentially non-operative factors. The response must be selective, since it is this element of selectivity which differentiates attentive behavior from the predominantly reflexive type. The familiar continuous reaction experiment seemed admirably suited to our purpose in that it required a selective reaction; the learning involved was extremely simple; and certainty and accuracy of response could be measured with relative ease.

Apparatus

The basic set-up chosen for this experiment was Dunlap's LVN apparatus described elsewhere in detail by the author, (20). This requires the subject "to react to the flashing of a row of miniature lamps by a specific movement in reference to each lamp in the row." (20). This "specific

movement" is the pressing of one of a row of telegraph keys corresponding to the row of lights.

The equipment consists of three main parts,—the switchboard with the lights and the telegraph keys, the mechanism which controls the flashes, and the kymograph which records both stimuli and responses.

Our switchboard was unique. In the original experiments this bit of the apparatus had for stimulus lights 4 small incandescent bulbs arranged in a horizontal row. In order to make the experience intrinsically interesting to our young subjects we placed these bulbs behind the eyes of two tin cats (identical twins) and fastened these cats side by side in such a way that the bulbs were equidistant and in a horizontal row. The cats were a neutral gray and were mounted in a box lined with dark gray flannel 47 x 31 cm. on the side. (See plates 1 and 2.) Each cat was 15 cm. in height, and each eye $2\frac{1}{2}$ cm. in diameter. The eyes, as they flashed, were a glowing green with small, round, red pupils. The children sat upon a stool facing the lights in such a position that the natural point of visual fixation was a spot (not marked) on the back of the box half way between the two middle lights. There was nothing within the range of vision that could compete with the light flashes in stimulus value.

The side of the box upon which the cats were mounted was set upon a stage 25 cm. above the table top on which we built up this part of the apparatus. Below the stage we lined up the 4 telegraph keys in such a way that each key was 28 cm. below and in a line with one of the eyes. These keys were fixed in a vertical position so that to tap them the child pushed forward instead of down. Upon the table top, in front of the row of keys, we put a low platform 5 cm. high covered with the same gray flannel which lined the box. On this the children rested their forearms while reacting with the fingers. On the hand rest, under the flannel, in front of each pair of keys we fastened two little wooden cylinders, about where the hands would lie. These served the double purpose of supporting the palms and of keeping the fingers from resting too near the keys.

The flashing of the lights in the eyes of the cats was controlled by a machine made in the Hopkins Laboratories according to Dunlap's specifications. Dunlap's description (20) follows:

> "(There are) four contact wheels, cut from brass, with bakelite filling between the contact lands. Spring brushes resting on the peripheries of these wheels provide reliable contacts and breaks. These contact wheels are rotated by four worm wheels on their respective shafts, all four worm wheels being driven from a single worm shaft on which are cut two worms, two worm wheels being driven from each worm. The worm wheels have respectively 101, 103, 105 and 107 teeth so that although the series represented by one wheel repeats itself after a certain number of minutes, the four series are steadily changing with relation to each other, and the four series return to their original relation only after 343, 824, and 705 rotations of the worm shaft. . . . . The stimuli may occur singly, or two, three or four may occur simultaneously. The lands of the contact wheels are of equal angular measure, but distributed on each wheel in a carefully planned irregularity. The length of time each stimulus lasts, (the length of time each lamp remains lighted), and the average interval between stimuli, in each of the four series is determined by the speed of the rotation of the worm-shaft." (20, p.

THE CATS, THE KEYS, AND THE KYMOGRAPH

CHRISTINE APPROXIMATELY IN THE REACTING POSITION

137). The worm shaft is driven by "a synchronous motor of a greatly improved model, so that the timing is extremely accurate."

The rate of stimulation was determined in a more or less arbitrary fashion. Several five and six year old children were tried on the apparatus before the experiment began in order to find out approximately how many flashes they could respond to in a working minute without showing signs of distress. On the basis of these observations the following rate was tentatively adopted: 4.5 flashes per key per minute, mean variation .12; average number of flashes for all keys per minute 18.05, mean variation 1.01. Each flash lasted approximately two seconds. The apparatus was set for this speed for the first 4 subjects, but this initial rate proved to be too slow. The children learned the task quickly, and, naturally, lost interest during the seemingly long waits between flashes. It happened one day toward the end of these first series that the adjustment of the motor was disturbed in such a way as to double the number of stimulations per minute. The child reacting was not disturbed, producing, on the contrary an excellent record. We, therefore, discarded the first 4 sets of records from the main series and established a standard procedure as follows: For the first three series, an initial rate of 4.5 flashes per key per minute, (m.v. .12); for series IV to X, double speed with an average of 10.4 flashes per key per minute, (m.v. .22). The duration of the short flash was approximately one second.

Stimuli and responses were registered by a kymograph of a model (designed and built in the Hopkins shop) which has 4 ink pen writings on continuous paper. This kymograph stands on the floor, on its own base. Each pen is hooked up in a circuit with one stimulus light and the corresponding response key in such a way that we obtained the following records for each separate light and key: "(1) A record of each stimulus whether reacted to or not. (2) A record of each reaction to a stimulus whether occurring before, during, or after the stimulus. (3) A record of each "wrong" reaction, each pressing of the wrong key." (20, p. 138.)

The entire apparatus was set up in a small room, 5 feet, 5 inches by 9 feet, 6 inches by 9 feet, which contained nothing else. Ventilation was by means of a window opening on an air shaft, and a door. The room was lighted by an electric bulb in the ceiling. The "Cat-box" was in a corner against a dull, buff-colored wall. Kymograph and motor were behind the reactors, and screened off. Fortunately both motor and kymograph worked with a minimum of noise.

Subjects

Our subjects were 20 white, five year old children, 12 girls and 8 boys. We limited ourselves to an age range of two months, using only those children whom we could test within the month preceding or following the fifth birthday. The difficulty of finding children of exactly the right age precluded the possibility of selection on any other basis. Public records of births, from which preliminary lists of five year olds might have been compiled, were not available to us. It was necessary, therefore, to hunt up our subjects one

by one. Most of these finally came through teachers in two public schools, through mothers in child study groups and through members of the Johns Hopkins faculty. When all other sources of supply failed to produce the right kind and number of children, we sought out populous streets and rang the door bells!

The group, as finally constituted, represented no one social level. The majority, 13, of the children were sons and daughters of business men. Of the remaining fathers, four were in

TABLE 1

Descriptive data for each subject in the experimental group

Nationality of All Children: American.
Chronological Age of All Children: 5 years ±1 month.

NAME	I.Q.	MENTAL AGE	NUMBER OF CHILDREN IN FAMILY	POSITION OF THIS CHILD IN FAMILY	SCHOOL EXPERIENCE	NATURE OF FATHER'S OCCUPATION	SPECIAL INFORMATION
Ada	123	6–2	2	Older	Kindergarten	Profession	
Amy	123	6–2	3	Second	No	Profession	
Bertha	103	5–2	1		Kindergarten	Business	
Betsy	120	6–0	1		Kindergarten	Business	
Brinton	132	6–6	2	Older	No	Business	
Bruce	83	4–2	1		No	Business	
*Christine	130	6–6	1		No	Business	
Deborah	145	7–2	1		Kindergarten	Profession	Father dead, mother working
Dolly	117	5–10	5	Youngest	No	Business	
Edith	80	4–0	2	Older	No	Mechanic	
Esther	145	7–2	2	Older	No	Business	
Harold	90	4–6	2	Younger	No	Business	
Jessie	102	5–2	4	Third	No	Profession	Father dead, mother working
John	105	5–3	1		No	Business	Parents divorced
Laura	123	6–2	2	Younger	No	Business	
Martin	80	4–0	6	Fourth	No	Street car conductor	
Molly	113	5–8	3	Oldest	Kindergarten	Profession	
*Peter	116	5–10	2	Younger	No	Business	
Robert	105	5–4	4	Youngest	No	Business	
*Spencer	113	5–8	2	Younger	Kindergarten	Business	

* Jewish.

professional work, one was a mechanic, and one a street railway conductor. In the remaining case, the father was dead.

Nothing definite was known of the nature of family relationships in the homes from which our children came. In 18 cases the child appeared to be living in a normal home environment. In one case the child and her widowed mother made their home with maternal relatives, the mother working. Also in one case, the parents were divorced, —the child living with its mother. Three of the children came from a large, fashionable apartment house, two from homes of apparent poverty, the rest from nice, "average," American families. Three of the youngsters were Jewish, the rest American Gentiles. Six subjects were only children. Five were already in kindergarten. This data are summarized in table 1. The names used in this report are fictitious.

Daily program

The experiment proper was, of course, the "working" of the Cats. In order to make the children's approach to the testing situation as easy and natural as possible this "working the Cats" was not emphasized in any way but was presented to them, without particular comment, as one of the lessons in a varied school program.

Through their mothers the youngsters were invited to attend two weeks of kindergarten at the University. Although constant for each one, school time was not the same for all subjects since in most cases our schedules had to be adjusted to household routines. For the same reason it was impossible to have equal numbers in the groups. Five of our children came alone, the others in twos and threes. The testing period lasted for ten days, every effort being made to have these days consecutive. In only one case was there a significant break in the series.

The school program was carefully planned to establish rapport. The children were called for each day at the time agreed upon, brought to school in an automobile, divested of hats and wraps, and taken into the "schoolroom." This "schoolroom" was, in fact, a corner of one of the big laboratories, screened off from the rest of the room. Here a rug, three small chairs, a long low table and one or two bright posters gave a workshop atmosphere to which the children responded readily; toys and constructive materials,—colored papers, crayons, scissors, paste, etc., were kept nearby in a convenient cupboard which formed one wall of our "room."

On his first day of school, each child was given the Stanford Revision of the Binet Scale, and was allowed to make friends with the Cats. For the rest of the days of each series the schedule was about as follows:

1. Construction with paper. 30 minutes. The projects were simple,—paper lanterns, posters, calendars, etc. The children worked intently and carried home the finished objects with pride. This preliminary lesson period gave the youngsters time to adapt to the new environment, and secured a positive coöperation which, in all cases, seemed to carry over into the experimental situation.
2. Toilet
3. Experiment proper,—"Working the Cats." 10 minutes

4. Stories and games. 30 minutes

From time to time, at this period, we introduced certain standardized performance tests. These gave us data which will be used elsewhere in working up another aspect of the experiment. They will not be referred to again in this paper.

We were fortunate in being able to win and to hold the interest of all of the children, each one of whom protested vigorously when his two weeks of school were finally over.

Experimental procedure

The procedure outlined for the experiment proper was rigidly followed. When a child was first taken in to see the cats he was allowed to feel them, to look about the room, if he so desired, and to watch the eyes flash for a while. He was then set squarely on the stool facing the apparatus and instructed in this way:

"You see these two tin cats? Each cat has two eyes, hasn't it? And each eye shines very bright when the little light goes on inside. Now look at these buttons (pointing to the keys). There is one for each eye. Show me which one goes with this eye (pointing to the one in the extreme left). Which one goes with this eye? With this one? With this one? All right. Now, I want you to put your hands here—this finger on this button, this finger on this button (demonstrating for all four). You are to learn to press the right button as soon as you see the light in the cat's eye. Press each button just once, *hard*, all the way down, and let it right up. Now. Let's try!"

A minute of preliminary practice was given, no records being taken of this. The experimenter then explained that, after working, the cats must rest, and dropped the black curtain over the box. After one minute, the curtain was raised again and commands were given sharply in the following order: "Hands ready." "Ready." "Go." At the word "Ready," the experimenter pressed the button which started the kymograph. We did not time the warning signals, but tried, in each case, to catch the child at the first instant of apparent readiness after the hands were in place.

Reactions were made continuously for one minute, timed with a stop watch. As soon as the minute was over, the experimenter called "Stop. Hands up," stopped the kymograph and let the curtain down over the cats. The child then rested for 60 seconds, without getting down from his stool. Each series consisted of 5 work minutes and 4 rest minutes in the order W—R—W—R etc. As previously stated, one series a day was given for 10 days as nearly consecutive as possible. All of the children, except one who dropped out because of illness, ran through the 10 series.

Instructions were repeated at the beginning of each day's experiment for the first four or five days. One or two of the subjects found it difficult to grasp the idea of the task and, therefore, received special help, on the first day, while the eyes were flashing. After the third day it seemed unnecessary to repeat instructions, so the children were simply given a reminder at the beginning of the first work period on each day following: "You remember what you do, don't you?" During the running of a series, children were not addressed or interrupted unless extreme need arose for encouragement or control.

RESULTS

The subjects were divided into two groups, A and B. Group A consists of the 4 children with whom the experiment was started. These subjects reacted to the initial rate or stimulation (4 flashes per light per minute) throughout all ten of the series. As has been stated, this rate proved too slow to hold the interest of the children after learning was established. The conditions of the experiment were, therefore, altered by doubling the original number of light flashes per minute beginning with Series IV.

This change in procedure made it necessary to discard the first four sets of records. Inspection of these data shows that actual performance was probably not much affected by rate of stimulation within the given range. Curves of efficiency and variability take about the same form for the four "slow" children as they do for the youngsters in the main experimental group. The kymograph reading, however, can give no picture of the difficulty we had in holding these children to their task. The dominant idea, see—light—push—button, was apparently not strong enough to span the relatively long waits between flashes. It seemed to fade about the middle of the interval leaving the youngsters receptive to all sorts of other stimuli,—to which they certainly responded. Every tack in the Cat box, every crack in the floor, every screw in the telegraph keys became astoundingly important, so that only the most extraordinary vigilance on the part of the experimenter kept the apparatus intact and the subjects present either in body or in spirit.

Our experience with Group A made it very clear to us that too little stimulation can be as disintegrating and destructive in a learning situation as too much,—a finding which probably has considerable significance. No other conclusions were drawn from this part of the experiment, which does not enter further into the discussion of results.

Group B consists of the 16 children who performed the experiment according to revised technique. The data obtained from these records have been analyzed statistically with reference to the three main lines of interest suggested in the statement of the general problem. The discussion which follows is based entirely upon the work of this group.

Measurement of attention

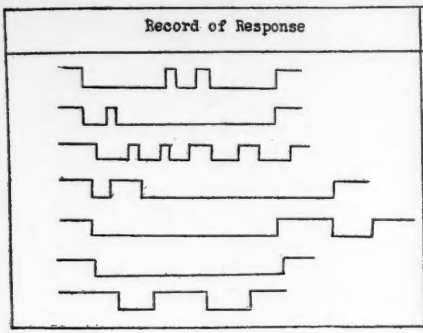
The value of the conclusions reached in this part of the study depends upon two things:

1. The validity of the assumption that attention means integration, and
2. The accuracy of the method of scoring devised.

The more carefully we observed the children's behavior the more inclined we were to feel that we had a good working hypothesis. Without exception, the subjects making the most successful adaptation to the experimental situation presented the classic picture of attentive behavior. The body was still, held firmly but not rigidly in a position of readiness. The hands rested lightly on the supports, fingers flexed for the forward thrust, each nicely in line with its key. The eyes were fixed intently on a point midway between the two cats on a

level with the lights. One felt, in the total organism, a complete readiness and a singleness of purpose. The light flashed, was perceived. The child responded instantly, following the pattern which he had set, but calling into play the special set of processes any one of these irrelevant bits of activity meant that a sub-group of processes was truant from the main constellation, and responding to other, more or less unrelated, stimuli.

Obviously, in this experimental situation, a measure of attention would



Record of Response	Description	Symbol	Score
	Right	R	20
	Incomplete	Ri	15
	Reduplicated	Rd	10
	Held	Rh	5
	Delayed	D	0
	Omitted	O	-20
	Errors	E	-20

FIG. 1. EVALUATION OF RESPONSES

SERIES I MINUTE A	LIGHTS							
	1		2		3		4	
	Type	Raw Score	Type	Raw Score	Type	Raw Score	Type	Raw Score
Responses	R	20	Rd	10	E	−20	E	−20
	R	20	Rd	10	E	−20	R	20
	Rd	10	Ri	15	Rd	10	Ri	15
	R	20	D	0	R	20	D	0
					Rd	10	Rd	10
					Ri	15		
					E	−20		
Totals.....		70		35		−5		25

FIG. 2. SAMPLE DATA SHEET

involved in selecting the particular finger to press the proper key.

Any changes in the nature of the response were on the negative side and resulted in a less than perfect performance. Talking, swinging the feet, lifting the hands, twisting the head,—be a graded scale with a maximum score for a perfect response and a series of decreasing values for imperfect responses, errors and omissions.

The method of scoring was not decided upon until after the first few sets of records had been critically

studied. This analysis showed that the children were making 7 distinct types of response:

1. Responses entirely correct.
2. Responses which began correctly but were held too long, i.e. after the flash was over.
3. Responses which were incomplete. In these the keys were pressed only part way down, or were pressed and released just as the stimulus light went out.
4. Responses which were correct, but repeated.
5. Delayed responses.
6. Wrong responses.
7. No response at all.

These recorded differences corresponded closely with the observed differences in the attentive behavior of the children. Each less than perfect response meant that the child had failed to be aware of, or to adjust to, one or more significant factors in the total situation,—had failed to this extent to integrate all relevant processes,—to attend.

A numerical equivalent was arbitrarily given to each of these 7 kinds of reaction. For convenience in scoring we adopted a scale with steps of 5, ranging from plus to minus 20. Fig. 1 shows each type of response as it inscribed itself upon the record, together with the symbol used to designate it and the value assigned.

The records were marked on the original kymograph paper and then transferred to data sheets. These data sheets were arranged in such a way that one could see at a glance how many and what sorts of responses were made to each one of the stimulus lights during each one of the working minutes. See fig. 2. By adding the figures in the separate columns, we were able to express numerically the total value of the reactions made to any one of the lights, and thus, by inference, measure the amount of attention which each light received.

Entries on the data sheets were, of course, raw scores, and did not in any way indicate the percentage of rightness of individual responses. Raw scores were, therefore, converted into true (T) scores. These true scores are quotients obtained by dividing the raw score for a given interval by the highest attainable score for the same length of time. To get these perfect scores, we multiplied the actual number of stimulations occurring in the given interval by 20.

Illustration: During Minute A, Series I, the lights flashed 16 times. A perfect response would be worth 16×20, or 320 points. Actually the responses were 20 in number,—5 perfect, 3 incomplete, 6 reduplicated, 2 delayed, 4 errors. The total value of these (See fig. 3) is 125. T score for Minute A, Series I, is 125 divided by 320, or .39.

The highest possible T score was 1.00; the lowest possible, an indeterminate minus depending on the amount of deduction for errors.

Basic calculations were made as follows:

1. T scores for each light for: (a) Each working minute, (b) Each series.

2. Mean T scores for: (a) Each light for each minute, (b) All lights for each minute, (c) All lights for each series.

3. Mean variations for : (a) Each light for each minute, (b) All lights for each minute, (c) All lights for each series.

There is a source of error in the scor-

ing which should probably be mentioned here. The same pens on the kymograph recorded both stimulations and responses. The two, therefore, appeared together on the same drawing. In most cases responses were easy to score, and stimulations easy to count. There were instances, however, particularly in cases where the children held the key too long, when the number of stimulations could not be determined with absolute accuracy. Since these instances were comparatively few, since all records were corrected by the same experimenter, and since each record was checked over three times, the results in the opinion of the writer, are not to be seriously questioned on this account.

Control of attention

This phase of the problem was studied from two points of view. We wanted to see whether the children actually gave increasingly better attention during the course of the experiment. We also wanted to find out whether progress, (if any) could be analyzed in such a way as to show steps in the acquisition of control.

The nature of our experimental situation favored both lines of inquiry. We had, in the first place, a series of responses that could be scored for any given unit of time. Central tendencies, therefore, could easily be ascertained by comparing scores. Secondly, we had a task requiring distribution of attention to a certain known number of discrete stimuli dispersed spatially and temporally in a manner controlled by the experimenter. This meant that the total response pattern could be broken up into single reactions to individual stimuli. One could thus discover, by studying these unit responses, whether attention was evenly distributed over the entire field, or tended to dwell upon parts of the whole. One could also discover, in this way, the relationship (if any) between this factor of distribution and the success of the complete reaction. At the same time one could study the influence upon the total performance of such known conditioning factors as the position of the lights.

We considered first the matter of absolute achievement. A graph was made for each child upon which were plotted consecutively the T scores for each work minute. Each set of 5 dots represented one series. Each curve was interrupted between Series III and IV to mark the point at which the rate of stimulation was accelerated. These first curves were smoothed by drawing over them second curves plotted from the means of the series. See fig. 3. Inspection of these graphs shows that every child improved, to some extent, in his total response to the test situation. This means, on the basis of our definition of attention, that each child improved in his ability to attend to this particular learning situation.

The data were next examined from the standpoint of variability, or relative achievement. The variability in mean T scores from minute to minute was calculated in the usual manner for each series. A third curve was then added to each chart, the plotting points being these mean variations. (Fig. 3.) A low mean variation for a given series meant that T scores for separate minutes in that series were nearly equal;

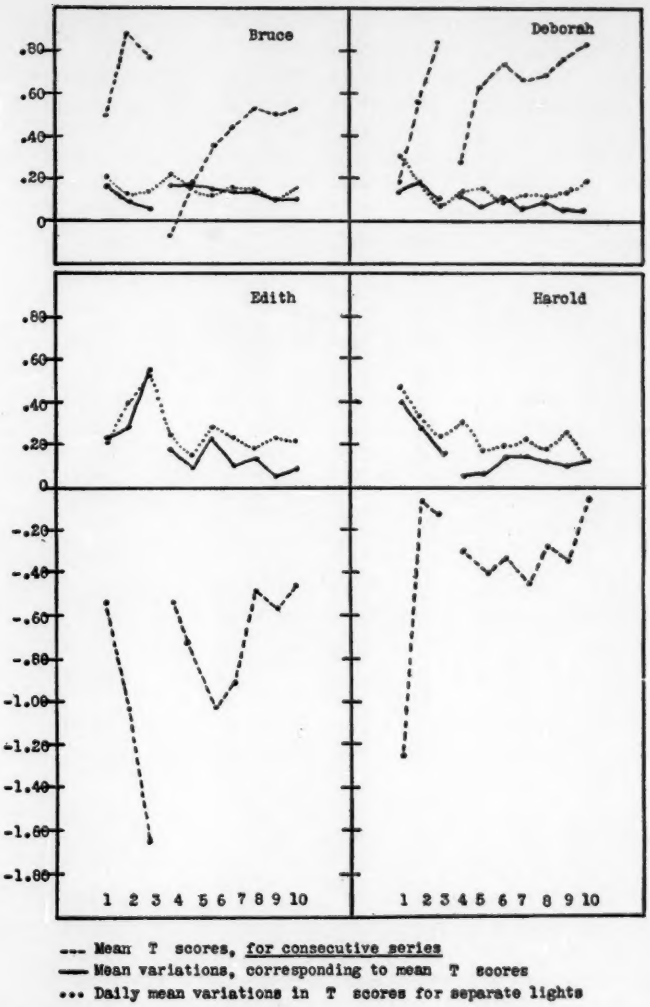


FIG. 3. SAMPLE CHARTS SHOWING PROGRESS IN EFFICIENCY, VARIABILITY AND POWER TO DISTRIBUTE ATTENTION

— — — Mean T Scores for Consecutive Series; —— Mean Variations, Corresponding to Mean T Scores; ..... Daily Mean Variations in T Scores for Separate Lights.

in other words, that performance was fairly even. A high mean variation, on the other hand, meant extreme differences in T scores from minute to minute during the series. Inspection of these variability curves indicated that in every case there was a marked reduction in variability during the progress of the experiment.

Composite curves of efficiency and variability show clearly the rise in the first and the drop in the second for the group as a whole. See fig. 4.

With these general trends in mind we analyzed the data in further detail, considering:

1. The nature of progress in relation to certain key series for both efficiency and variability.

2. Relationships implicit in the data.

3. Unitary responses to individual stimuli (the separate lights). These were studied from the standpoint of: (a) Distribution of attention to the several lights in the field, and (b) The influence of position of stimuli upon the stimulus value of individual lights.

There were, because of the nature of the test situation, 3 critical series in each full set of reactions,—I, IV, and X. These represented the attack, adaptation to the changed rate of stimulation, and the finish. Was X uniformly better than I? Was there a break at IV? Where were the best scores made? What was the range of initial mean scores, final mean scores, best mean scores? What was the range of scores for initial, final and lowest mean variability? At what point was variability reduced to its lowest terms? We made some headway in all of these directions.

TABLE 2

Mean T scores for key series

NAME OF CHILD	SERIES			
	I	IV	X	Best
Ada	−1.95	−.21	.28	.37
Bertha	− .01	−.38	.10	.14
Bruce	.51	−.06	.52	.54
Christine	.42	−.25	.14	.14
Deborah	.19	.28	.83	.83
Dolly	.46	.00	.61	.61
Edith	− .66	−.54	−.47	−.47
Esther	− .60	.20	.27	.42
Harold	−1.25	−.31	−.07	−.07
Jessie	− .73	−.67	−.56	−.56
John	− .98	−.53	−.57	−.41
Laura	− .03	−.38	.40	.42
Martin	−1.66	−.68	−.79	−.68
Peter	− .23	−.45	−.20	−.19
Robert	−1.61	−.91	−.44	−.32
Spencer	− .16	−.35	.53	.53
Range for each series	−1.95 to .51	−.91 to .38	−.79 to .83	−.68 to .83

TABLE 3

Mean variations in T scores for key series

NAME OF CHILD	SERIES			
	I	IV	X	Best
Ada	.46	.09	.05	.05
Bertha	.06	.21	.12	.05
Bruce	.17	.17	.10	.10
Christine	.12	.16	.13	.10
Deborah	.15	.12	.06	.06
Dolly	.19	.15	.15	.15
Edith	.23	.19	.09	.07
Esther	.48	.19	.20	.04
Harold	.41	.06	.12	.06
Jessie	.37	.19	.13	.11
John	.28	.08	.21	.08
Laura	.23	.06	.04	.04
Martin	.38	.19	.11	.09
Peter	.23	.06	.08	.06
Robert	.29	.15	.23	.05
Spencer	.31	.10	.05	.05
Range for each series	.48 to .06	.21 to .06	.23 to .04	.15 to .04

TABLE 4

Best scores for efficiency and variability in relation to the series in which they occur

NAME OF CHILD	EFFICIENCY		VARIABILITY	
	Best score	Series in which this occurs	Best score	Series in which this occurs
Ada	.37	9	.05	10
Bertha	.14	7	.05	9
Bruce	.54	8	.10	10
Christine	.14	10	.10	7
Deborah	.83	10	.06	10
Dolly	.61	10	.15	4
Edith	−.47	10	.07	9
Esther	.42	9	.04	8
Harold	−.07	10	.06	4
Jessie	−.56	10	.11	9
John	−.41	7	.08	4
Laura	.42	7	.04	10
Martin	−.68	4	.09	9
Peter	−.19	8	.06	4
Robert	−.32	9	.05	7
Spencer	.53	10	.05	10

TABLE 5

Distribution of best scores according to series

SERIES	EFFICIENCY		VARIABILITY	
	Number of best scores	Percentage	Number of best scores	Percentage
4	1	.06	4	.25
5	0	.00	0	.00
6	0	.00	0	.00
7	3	.19	2	.13
8	2	.12	1	.06
9	3	.19	4	.25
10	7	.44	5	.31
Totals....	16	1.00	16	1.00

were higher than initial T scores for the same subjects. The rise, however, was by no means regular. Special analysis of the first three series for all records shows that 10 of the curves rose rapidly, 1 remained on a plateau, and 5 went decidedly down.

b. There was a decided break for every child between Series III and IV. This did not mean the same thing in every case, however. Every one of the 10 subjects who gained rapidly for the first three days was set back when the rate was changed. The

TABLE 6

Changes in mean scores for efficiency and variability with change in rate of stimulation

NAME OF CHILD	MEAN T SCORES				MEAN VARIATION			
	Series III	Series IV	Gain	Loss	Series III	Series IV	Gain	Loss
Ada	.45	−.21		1	.18	.09	1	
Bertha	.07	−.38		1	.13	.21		1
Bruce	.78	−.06		1	.07	.17		1
Christine	.25	−.25		1	.19	.16	1	
Deborah	.85	.28		1	.10	.12		1
Dolly	.73	.00		1	.09	.15		1
Edith	−1.65	−.54	1		.55	.19	1	
Esther	.38	.20		1	.17	.19		1
Harold	− .12	−.31		1	.17	.06	1	
Jessie	− .74	−.67	1		.37	.19	1	
John	−1.60	−.53	1		1.12	.08	1	
Laura	.32	−.38		1	.17	.06	1	
Martin	−2.31	−.68	1		.38	.19	1	
Peter	.18	−.45		1	.11	.06	1	
Robert	−2.44	−.91	1		1.22	.15	1	
Spencer	.43	−.35		1	.16	.10	1	
Total number gained or lost			5	11			11	5
Percentage			31%	69%			69%	31%

1. Analysis of the Nature of Progress. (Tables 2 to 6 inclusive.)

The general conclusions which were reached when the data were analyzed from this point of view may be stated as follows:

a. In all instances, final T scores

child who had heretofore made no progress, began to gain. Of the 5 children who had been losing ground, 1 continued on down hill, but 4 made significantly better scores on the fourth day than on the third.

c. There were two kinds of high

scores. There was the high mark obtained within the first three series by the child who adapted immediately to the task and took full advantage of the slow rate of stimulation to run up a good score. More important than this was the highest T score obtained on the relatively long stretch between IV and X after the rate of stimulation was doubled. It is this latter which will be regarded as the best score and referred to as such throughout the rest of this paper. These best scores distributed themselves throughout the several series from IV to X, but tended to appear toward the end. Seven, or 44 per cent, of them occurred in Series X. This probably indicates that most of the children were still improving in ability to attend the given situation when the experiment ended.

d. The range of mean scores in each group was fairly wide.

Initial scores ranged from −1.95 to .51
Final scores ranged from − .79 to .83
Best scores ranged from − .68 to .83

TABLE 7

Correlations for each child between efficiency and variability, based on rank order comparisons of daily mean T scores and daily mean variations

NAME OF CHILD	r	P.E.
Ada	.32	±.20
Bertha	.29	±.20
Bruce	.81	±.08
Christine	.15	±.22
Deborah	.64	±.13
Dolly	.21	±.21
Edith	.70	±.11
Esther	.82	±.07
Harold	−.03	±.22
Jessie	.84	±.07
John	.82	±.07
Laura	.47	±.17
Martin	.50	±.17
Peter	.18	±.22
Robert	.71	±.11
Spencer	.38	±.19
Mean	.49 ±.17	
Range	−.03 ±.22 to .84 ±.07	

TABLE 8

Intercorrelations between mean T scores for key series

SERIES COMPARED	r	P.E.
Initial and Final	.64	±.10
Initial and Best	.66	±.10
Best and Final	.98	±.01

TABLE 9

Intercorrelations between mean variability scores for key series

SERIES COMPARED	r	P.E.
Initial and Final	.09	±.18
Initial and Best	−.31	±.16
Best and Final	.39	±.15

The minus scores are chiefly due to omissions and errors. Improvement means reduction of error and increasing accuracy in response.

e. The range in variability of score is as striking as the range in mean scores.

Initial mean variations range from .48 to .06
Final mean variations range from .23 to .04
Lowest mean variations range from .15 to .04

TABLE 10

Intercorrelations between scores for efficiency and variability

MEASURES COMPARED	r	P.E.
Initial mean T score and initial mean variability..	.81	±.06
Final mean T score and final mean variability....	.40	±.15
Highest mean T score and lowest mean variability..	.24	±.17

TABLE 11

Correlations between I.Q.s and mean T scores for key series

MEASURES COMPARED	r	P.E.
I.Q. and initial mean T score.....	.30	±.16
I.Q. and final mean T score..	.60	±.11
I.Q. and best mean T score..	.60	±.11

f. A study of the variability in score from series to series proved particularly interesting. Two children had records showing the lowest mean variation in Series III. In all other cases, the lowest mean variation was attained in a later series. These low variations were found somewhat earlier in the learning than the high scores for efficiency. Four of them are in Series IV, and only 5, or 31 per cent, in Series X. Evidently the steadying down in performance came before the high point in achievement was reached.

2. Study of Relationships Implicit in the Data (tables 7 to 12 inclusive). Certain questions of relationship next arose, suggested by the data already accumulated. Was the child who gave the best performance in the beginning the child who finally achieved the best score, the highest final score? Was the child with the highest I.Q. the child who made the best initial score, the best score, the highest final score? With regard to variability, was the child who showed least variation in the first series the child who showed least at the end? Was there any discoverable connection between initial scores and best, i.e. lowest, scores for variability? What, in general, was the relation between efficiency in total performance and variability? Which is the better basis for predicting how a child of this age will follow through a task,—his I.Q. or the quality of his first attack upon the problem?

TABLE 12

Correlations between I.Q.s and mean variabilities for key series

MEASURES COMPARED	r	P.E.
I.Q. and initial mean variability.....	.12	±.17
I.Q. and final mean variability.....	.09	±.18
I.Q. and lowest mean variability.....	.36	±.15

Because of the small number of cases used in this study, any correlations calculated were bound to have large probable errors. Certain coefficients were worked out by Pearson's rank

order method, however,—$r = 1 - \frac{6\Sigma d^2}{N(N^2 - 1)}$; P.E. $= .7063 \frac{1-r^2}{\sqrt{N}}$. These measures are gross, but probably accurate enough to show tendencies. The following coefficients of correlation were obtained:

a. The correlation between efficiency of performance and variability for each individual child. In 8, or 50 per cent, of the cases this correlation was. 50 or over; being .80 or above in 4 instances. For at least half of the children, then, the best performances tended to be the most even.

b. Correlations between initial, final and best scores for performance. These show, in general, a tendency for the child who is successful on the first series to be successful throughout. There is a very high correlation, .98 ± .01 between final score and best score, indicating that the last series was usually the best.

c. Correlations between initial, final, and lowest scores for mean variability. These show a negligible amount of coincidence. The child whose approach is erratic may pull himself together and later be quite steady. Correlation between scores for final variability and least variability is low, .39 ± .15, which suggests that the steadying down comes somewhere before the last series.

d. Correlations between group scores for efficiency and variability. These give a high positive correlation, .81 ± .06, between initial efficiency and initial variability, but nothing else significant. Just as, in individual cases, the best series tended to be the most even, so here for the group, the best initial performances tended to show the least variability. As the other correlations would lead one to suppose, there is a very slight relationship between final performance and final variability. One is somewhat at a loss, however, to explain the very low correlation, .24 ± .17, between the very best scores and the lowest variabilities.

e. Correlations between I.Q. and efficiency, and between I.Q. and variability. These would seem to indicate that the I.Q. correlates fairly well with either best or final performances (these correlate with each other), but not appreciably with any of the other measures. A high I.Q. on this age level may be a good reason for expecting ultimate success with this sort of problem, but does not guarantee a good first performance. Conclusions are tentative because of the relative unreliability of these early I.Q.'s.

3. Detailed Analysis of Unitary Responses. The nature of the experimental set-up was peculiarly favorable for this part of the study. Report of the analysis follows:

a. Distribution of attention to disparate stimuli. It will be remembered that adequate response to this test situation involved a distribution of attention to 4 stimulus lights, and that the kymograph recorded the reactions to these separately. On the data sheets these lights were numbered 1, 2, 3, and 4 beginning with the light on the left. As previously explained, the score for each response to each flash was entered on the data sheet under the number corresponding to that light. In the scores for each work minute for each individual position we thus had a numerical measure

of distribution of attention which seemed fairly satisfactory. If light 1 were found to have a consistently higher score than light 3, one would probably be justified in assuming that light 1 received a greater share of attention. If on the other hand, all 4 lights received approximately equal scores, for a given interval, one would assume that atention during that interval was more or less evenly distributed over the whole field.

In order to obtain a measure of the variability in response to separate lights we proceeded as follows: We calculated the mean score per light per minute, and the mean variation of these scores. We then computed the average of the mean variations for each day. These averages we called coefficients of distribution,—C.D. These averages are the plotting points on charts which represent the "distributability" of each child for each day. (Table 13.) Inspection of these charts shows that in every single case there is a marked difference between the first and last coefficient, which must mean that an original tendency to concentrate on one or two lights alone has been more or less overcome. The curves have the same general shape for all 16 subjects. In 15 of the cases we find a more or less abrupt drop through the first four days to a level upon which the rest of the plotting points fluctuate. Learning apparently takes place fairly rapidly.

Since the first three days of each experiment were days of adjustment for the children, behavior was probably influenced by many extraneous factors which later ceased to operate. At any rate, the raw curves fluctuate ex-

TABLE 13

Averages of the daily mean variations in scores for distribution of attention to each light for each minute

NAME OF CHILD	SERIES									
	1	2	3	4	5	6	7	8	9	10
Ada	.73	.37	.29	.20	.25	.28	.21	.25	.23	.15
Bertha	.35	.28	.24	.18	.22	.15	.15	.15	.16	.16
Bruce	.19	.13	.14	.22	.16	.12	.16	.15	.10	.16
Christine	.28	.20	.29	.22	.11	.19	.17	.14	.27	.21
Deborah	.30	.18	.07	.14	.15	.09	.12	.11	.13	.19
Dolly	.33	.25	.16	.28	.18	.21	.19	.12	.18	.16
Edith	.21	.39	.52	.24	.15	.28	.23	.18	.23	.22
Esther	.69	.36	.26	.24	.22	.15	.15	.15	.12	.12
Harold	.47	.38	.24	.30	.17	.19	.22	.18	.26	.13
Jessie		.42	.63	.22	.16	.23	.19	.19	.18	.25
John	.43	.49	.47	.18	.39	.27	.24	.32	.40	.39
Laura	.32	.24	.42	.21	.17	.20	.18	.16	.21	.11
Martin	.73	.47	.78	.20	.32	.22	.22	.24	.31	.13
Peter	.29	.34	.29	.13	.16	.16	.20	.21	.12	.18
Robert	.64	.72	1.01	.45	.26	.21	.24	.22	.20	.25
Spencer	.34	.26	.18	.20	.25	.16	.16	.13	.22	.09

tremely during this period. In order, therefore, to be as fair as possible in measuring the difference between initial and final distribution of attention to this problem, we averaged the first coefficients of each series, and the last three for purposes of comparison. Obtaining, for each child, the actual difference and the percentage of difference between these derived coefficients (table 14), we find that (1) The percentage of reduction ranges from 7 per cent to 72 per cent, and that (2) The average drop in variability in score for separate lights is 45 per cent.

In order to relate this finding to other measures already obtained the following correlations were calculated, the rank order method again being used.

1. The correlation, in the case of each individual child, between measures of distribution of attention and (a) Measures of efficiency, (b) Measures of variability.

These do not give conclusive results. The correlations between efficiency and ability to distribute attention range from .93 ± .03 to −.81 ± .08, average, roughly .49. In 7 of the cases the correlation is .50 or over. (Table 15.)

TABLE 14

Comparison of initial and final variability in distribution of attention to the four lights. C.D. = coefficient of distribution. See text

NAME OF CHILD	INITIAL C.D.	FINAL C.D.	GAIN	PERCENTAGE OF GAIN
Ada	.46	.21	.25	.54
Bertha	.29	.16	.13	.45
Bruce	.15	.14	.01	.07
Christine	.26	.21	.05	.19
Deborah	.19	.11	.08	.42
Dolly	.25	.15	.10	.40
Edith	.38	.21	.17	.45
Esther	.41	.13	.28	.68
Harold	.35	.19	.16	.45
Jessie*	.53*	.21	.32	.60
John	.46	.37	.09	.20
Laura	.33	.16	.17	.51
Martin	.66	.23	.43	.65
Peter	.30	.17	.13	.43
Robert	.79	.22	.57	.72
Spencer	.26	.15	.11	.42

* Based on 9 Series, (II to X inclusive).

The correlations between variability in performance and ability to distribute attention range from .90 ± .04 to −.27 ± .21. The average is approximately .74. Here with 8 of the children the correlation is .50 or over. See table 15.

2. Correlations, for the group, between measures of efficiency and distribution of attention. These are all positive, and fairly high, (table 16.)

3. Correlations, for the group, between measures of variability and distribution of attention. Two of these are positive and one not significant (table 17). The correlation between the scores for mean variability on the initial series, and the initial coefficients of distribution is fairly high, .71 ±.09. There is no correlation, for the group, between the scores for low-

TABLE 15

Correlations for each child between daily mean variation in distribution of attention and daily mean measures of efficiency and variability

NAME OF CHILD	CORRELATIONS BETWEEN DAILY MEAN T SCORES AND DAILY MEAN VARIATIONS IN DISTRIBUTION OF ATTENTION		CORRELATIONS BETWEEN DAILY MEAN VARIATIONS IN T SCORE AND DAILY MEAN VARIATIONS IN DISTRIBUTION OF ATTENTION	
	r	P.E.	r	P.E.
Ada	.38	±.19	.90	±.04
Bertha	.22	±.21	−.25	±.21
Bruce	.35	±.20	.47	±.17
Christine	−.38	±.19	−.27	±.21
Deborah	.55	±.16	.12	±.22
Dolly	.26	±.21	.44	±.18
Edith	.66	±.13	.67	±.12
Esther	.64	±.13	.60	±.14
Harold	.15	±.22	.43	±.18
Jessie*	.25	±.22	.50	±.16
John	.93	±.03	.90	±.04
Laura	.36	±.19	.51	±.16
Martin	.78	±.09	.45	±.16
Peter	−.81	±.08	.04	±.22
Robert	.83	±.07	.75	±.10
Spencer	.56	±.15	.59	±.15

*Based on 9 Series only, II to X inclusive.

TABLE 16

Correlations between daily mean variations in distribution of attention and mean T score for key series

MEASURES COMPARED	r	P.E.
Initial mean distribution of attention and initial mean T scores	.78	±.13
Final mean distribution of attention and final mean T scores	.54	±.13
Best mean distribution of attention and best mean T scores	.77	±.07

TABLE 17

Correlations between daily mean variations in distribution of attention and mean variations in T scores for key series

MEASURES COMPARED	r	P.E.
Initial mean distribution of attention and initial variability	.71	±.09
Final mean distribution of attention and final variability	.48	±.13
Best mean distribution of attention and lowest variability	.08	±.17

est variability and most even distribution. This may be because it is possible to give well distributed attention to a total stimulus pattern for one testing minute, and yet be essentially inattentive to the whole situation the next, which would mean a high variability for the series even though the coefficient of distribution were very low.

4. Correlations between I.Q. and ability to distribute attention are all low. Here again the significance of the findings is not clear because of the well known unreliability of the I.Q. in these early age ranges, (table 18).

TABLE 18

Correlations between I.Q. and ability to distribute attention

MEASURES COMPARED	r	P.E.
I.Q. and initial mean distribution of attention....	.07	±.18
I.Q. and final mean distribution of attention.....	.05	±.17
I.Q. and best mean distribution of attention.....	.42	±.14

Evidently it is possible to learn to distribute attention fairly evenly over a number of elements in a given field. It also seems to be true that whatever the I.Q. measures in these particular children does not help them much in learning to adjust well to a complication of stimuli. It would be extremely interesting to know what capacities do facilitate such an adaptation and what limits the extent to which this can be accomplished.

b. Influence of position of stimuli upon attention. In order to determine whether or not the position of any given light influenced its stimulus value, we analyzed the reactions to the various flashes in terms of theoretical probability. Did any particular light tend to receive the highest scores, i.e. the largest number of correct responses? To determine this we ranked each light for each work minute according to excellence of score, rank 1 being the highest score obtained during one work minute by any one light. We then constructed a 16-fold table in which we entered each light once for every response according to rank and number, (table 19). The theoretical probability that any given light will appear in any one of the four ranks is the same for each, since the number of items (responses) is sufficiently large (3328). This theoretical frequency was calculated and entered in the cells, (figures in italics). The comparison with the theoretical fre-

TABLE 19

Contingency table showing the relation between the theoretical and observed frequency with which each light occupied a given rank according to excellence of score. See text

RANK	POSITION OF LIGHT			
	1	2	3	4
1	*208* 223.5	*208* 147.5	*208* 222	*208* 239
2	*208* 223	*208* 215	*208* 198	*208* 196
3	*208* 213	*208* 209	*208* 218.5	*208* 191.5
4	*208* 172.5	*208* 260.5	*208* 193.5	*208* 205.5

Top figure (italics) in each cell = theoretical frequency. Lower figure = observed frequency.

quency of the actual number of times that the given stimulus light actually occupied a given rank shows that responses to individual lights follow fairly closely a chance distribution. The coefficient of contingency has not been calculated for the entire table since inspection of separate cell contingencies seems to show that the position of the stimulus light does not have a determining influence in directing the attention of these young children in this experimental situation. There is a slight tendency to favor the right, and a somewhat more pronounced tendency for the second light from the left to be neglected.

Individual differences

Throughout the experiment, individual differences in the behavior of the children were striking. In so far as these could be analyzed they seemed to be due to fundamental differences in personality development or to emotional upsets resulting from experiences outside of the laboratory. Previous training in obedience, coöperation and self-control helped far more than a high I.Q. in meeting this new situation. Two children who seemed especially well taught in these respects showed remarkably even distribution of attention on the first testing day although one I.Q. was 83 and the other 145. Another child with an I.Q. of 145 scattered extremely during the first three series and learned very slowly to attend to the total stimulus pattern.

The emotional upsets were profoundly disturbing to the experiment, but in most cases we did not know our children well enough to be sure of the causes. In some instances, however, we knew enough about the home situations to be able to guess at the reasons for a child's disorganization. The ups and downs in all of Christine's curves are a more or less accurate picture of a prolonged excitement over the coming of a new baby. The abrupt rise on her chart, showing very poor control of attention on the eighth day, coincides with the arrival of the infant. Bertha is a child who comes from a home in which there was constant friction between the parents. She was a sensitive child who was rapidly becoming neurotic in her attempt to adjust to the stresses and strains of a chaotic environment. Constant jarring kept the child so stirred that she was never able to make a satisfactory adjustment to the experiment. Harold was a totally undisciplined little boy who ruled his family by temper tantrums. Thwarting in any way demoralized his powers of self-organization and affected the quality of his attention to a marked degree.

One important factor in the handling of these children did not receive adequate consideration. We had no good check on physical condition, and were not able to arrange for one. We, therefore, do not know to what extent possible organic disturbances may have influenced response. It is true that the one child who was obviously ill with a cold during most of his experiment made very satisfactory progress, both in efficiency of total performance and in learning to control distribution of attention.

We were interested to discover that, even with these young children, the intensity of the overt behaviour was

not a reliable indication of the real extent of the emotional disturbance. In one or two instances an erratic record on the kymograph was our first clue to a profound distress of spirit which later expressed itself in bitter tears.

One hesitates to generalize on the basis of so little real evidence, yet it seems clear, from these observations,

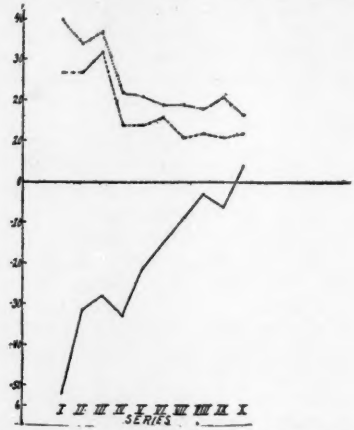


FIG. 4. CHART SHOWING COMPOSITE CURVES FOR EFFICIENCY, VARIABILITY AND POWER TO DISTRIBUTE ATTENTION

..... Mean Scores for Distribution of Attention (Distributability); — — — Mean Variations (Variability); ——— Mean T Scores (Efficiency).

that a condition of emotional stability is essential for the development and control of attention.

SUMMARY AND CONCLUSIONS

In this study of attention in five year old children we have defined attention as integration, or integrated state. On the basis of this definition, we have assumed that one is measuring attention if one measures adequacy of response. We have here attempted to measure such adequacy in a situation involving continuous discriminative reaction to four stimulus lights.

We have found that:

1. All children tested improved in their ability to perform the task required.

2. This improvement was closely accompanied by reduction in variability of performance.

TABLE 20

Recapitulation of mean scores for efficiency, variability, and power to distribute attention

SERIES	MEAN T SCORES	DAILY MEAN VARIATION IN T SCORES	DAILY MEAN VARIATIONS IN DISTRIBUTION OF ATTENTION
1	−.52	.27	.40
2	−.31	.27	.34
3	−.28	.32	.37
4	−.33	.14	.22
5	−.21	.14	.21
6	−.16	.16	.19
7	−.09	.11	.19
8	−.03	.14	.18
9	−.06	.12	.21
10	+.04	.12	.17

3. Both variability and level of final achievement appear to be functions of the ability to distribute attention over a field, an ability which is, in itself, a point of individual difference and subject to modification.

4. There is no evidence that position is a determinant of attention. The picture is, rather, one of original fixation on one or more details (in this case, one of the four positions) with a gradual apprehension and control of all the elements involved.

5. A condition of emotional stability appears to be essential for success-

ful response in all situations requiring concentration of attention.

Fig. 4 (table 20) gives a complete summary of the whole experiment. It shows, in a striking way, the convergence of the three curves representing efficiency, variability and power to distribute attention. One cannot escape the conclusion that the three have a functional relationship.

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The Acquisition of Motor Skill in Young Children

II. The Influence of Specific and of General Practice on Motor Skill[1]

J. Allan Hicks

A RECENT paper (3) gave a report of a study of some aspects of the development of motor coordination in young children as measured by the moving target test. From the analysis of the data on this test it was found that both a practice and a control group made gains in average scores from the initial to the final tests, but that the difference in gains was not significant. These results were interpreted as an indication that the improvement in motor ability found in both groups probably resulted primarily from the operation of common factors such as structural maturation and general practice which had a direct bearing on the specific skill. On the moving target test investigation 60 children, including 12 three-year-olds, 18 four-year-olds, 18 five-year-olds, and 12 six-year-olds were divided into 2 groups of 30 children each so that the average scores and the standard deviations of the scores were equal for the 2 groups. Both groups were also made comparable in age and sex distributions. One group—the practice group—repeated the test once a week for eight weeks, while the other—the control group—was not tested during this period. At the end of this period both groups repeated the test twice on successive weeks. In no case was a child instructed in techniques of improving skill in throwing.

The present paper is a report of a study carried on parallel with the moving target investigation which also bears upon the problem of the relation of specific practice to the increase of motor skill. Three motor tests—the strength (2), the perforation (1), and the tracing path (4), were each given twice to the same children used in the target investigation—once during the period when the initial target test was given and again when the final target test was given. In order to make the changes in scores on the 4 tests comparable the time between the first and last tests was kept as nearly equal as possible for each child. The average lapse of time for the practice group on the four tests was 83 days and for the control 82 days.

The object in giving the strength, perforation and tracing path tests was

[1] This study was completed while the author was a scholar in child development of the National Research Council at the Iowa Child Welfare Research Station.

to compare the gains of children on motor tests on which they were not practiced with their gains on the target test on which half were given specific practice and half were not. As score units on the different tests are not directly comparable the results were evaluated by expressing the gain as a multiple of the standard deviation on the initial test.

As the strength, perforation and tracing path tests have been described in detail by the investigators designing them, Blackhurst (2), Baldwin and Stecher (1) and Wellman (4), they will be but briefly summarized in this paper.

STRENGTH TEST

The strength test was devised to measure strength of arm and shoulder pull. The child is required to lift weights weighing 15¾ pounds a set from the floor by pulling downward on a rope and pully arrangement which gives a mechanical advantage of two to one. The child first pulls with his right arm alone, then with his left alone and finally with both arms at the same time on separate sets of weights. This procedure is repeated 3 times. The number of centimeters the child lifts the weights from the floor is recorded as the score.

PERFORATION TEST

The perforation test measures the motor coördination required to punch out small broken circles on a piece of ordinary bond paper containing 50 such broken circles arranged in checker board fashion. The paper is held taut between 2 frames clamped to the table so that the child can readily punch out the holes with a small stick. The score is the average number of holes punched out in 3 trials of 1 minute each.

TRACING PATH

The child is required to draw a line with a pencil between 2 printed lines 25 cm. long and 5 mm. apart at one end and 1 mm. apart at the other. In the present study four of the directions reported by Wellman were used and for the preferred hand only. The sequence of directions repeated three times for each test was: (1) vertical and downward, (2) horizontal and to the right, (3) horizontal and to the left, (4) diagonal and downward to the right. The score on this test is the percent of the child's line which is within the tracing path.

RESULTS

Table 1 gives the average scores on the initial and final tests and the gains in average scores for the moving target, strength, perforation and tracing path tests. The group designated as the practice group for each test is the group of 30 children who were given weekly practice on the target test. As previously explained, the gains are given both in score units and as multiples of the standard deviation on the first test. The table also gives the difference in gains of the practice and control groups in score units for each of the four tests with the statistical reliability of the difference.

An explanation of each column in this table, as numbered, follows:

1. Group: The results for the practice group are given in comparison with the results for the control group for the different tests. The group designated as the practice group on the

strength, perforation and tracing path tests is the group given weekly practice only on the target test. The composite results of the children in both groups are also given.

2. Number: The number of children in each group. The records are for the same children on the different tests.

3. Mean 2: The average score made by each group on the final test. For the moving target test the score of an individual was the average of 10 throws at the target. The score for each throw was obtained by subtracting from 25 the number of inches from the center of the target that the ball struck. For the strength test an individual's score was the average pull in centimeters of 3 trials with the right arm alone; for the perforation test, the average number of holes punched in 3 successive trials; and for the tracing path test, the average percent of the child's line within the path on 3 trials on each of the four directions previously mentioned.

4. Mean 1: The same as column 3 except the data are for the initial tests in each case.

5. Gain: The gain in score units obtained by subtracting mean 1 from mean 2 for each group. For example, these results show for the target test that on the average the 60 children threw 1.6 inches closer to the center on the final test than on the initial test. On the strength test the children pulled up the weights 3.5 centimeters farther; on the perforation test they punched out 7.2 more holes; and on the tracing path they marked out of the paths 1.1 percent more.

6. S. D. Dist. 1: The standard deviation of the distribution of scores on the first test, or the measure of digression of scores from mean 1.

7. Gain ÷ S. D. Dist. 1: Column 5 divided by column 6. This gives the gain of each group on each test in terms of the standard deviation on the initial test. Assuming comparable distributions of talent for the groups under comparison, this gives a measure which is independent of different score units and so directly comparable for different tests.

8. S. D. of gain: The standard deviation of the gain given in column 5 as obtained by use of the formula for correlated measures,

$$\gamma \text{ Diff.} = \sqrt{\gamma^2 \text{ Av. } 1 + \gamma^2 \text{ Av. } 2 - 2r12\, \gamma \text{ Av. } 1\, \gamma \text{ Av. } 2}$$

The correlation coefficients between initial and final scores of three to six-year-old children which were used to compute the standard deviations of gains were as follows:

TEST	GROUP	NUMBER OF CHILDREN	COEFFICIENT
Moving target	Practice	30	.87 ± .03
Moving target	Control	30	.70 ± .06
Moving target	Combined	60	.70 ± .04
Strength	Practice	30	.91 ± .02
Strength	Control	30	.90 ± .02
Strength	Combined	60	.91 ± .02
Perforation	Practice	30	.78 ± .05
Perforation	Control	30	.60 ± .08
Perforation	Combined	60	.66 ± .05
Tracing path	Practice	30	.87 ± .03
Tracing path	Control	30	.93 ± .02
Tracing path	Combined	60	.91 ± .02

9. Gain ÷ S. D. of gain: Column 5 divided by column 8. This gives a di-

rect comparison of the size of the gain relative to its standard deviation. If this quotient is approximately 3.0, the gain may usually be considered statistically significant.

10. Diff. in gains: The gross gain of the practice group (column 5) minus the gross gain of the control group (column 5). This is the difference in gains for the 2 groups in score units.

11. S. D. of diff. in gains: The standard deviation of the difference obtained in column 10, computed by use of the formula,

$$\text{sigma difference in gains} = \sqrt{\gamma^2 \text{ gain } 1 + \gamma^2 \text{ gain } 2}$$

The sigmas of gains in column 8 were used.

12. Diff. in gain ÷ S. D. of diff: Column 10 divided by column 11. This is a measure of the statistical reliability of the difference in gains between the practice and control groups.

When table 1 is examined in detail the following points seem of most significance:

1. The means are lower for the control group on both the initial and final test on the moving target. The girls in the five-year control group made especially low scores on the strength, perforation and tracing path tests.

2. The standard deviations for the

TABLE 1

Increase in skill on motor tests with and without specific practice

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GROUP	NUMBER	MEAN 2	MEAN 1	GAIN	S.D. DIST. 1	GAIN / S.D. DIST. 1	S.D. OF GAIN	GAIN / S.D. OF GAIN	DIFF. IN GAINS	S.D. OF DIFF. IN GAINS	DIFF. IN GAIN / S.D. OF DIFF.
Moving target test											
Practice	30	13.6	11.7	1.9	5.7	0.33	0.33	3.2			
Control	30	13.0	11.7	1.3	5.6	0.23	0.73	1.8	0.6	0.95	0.63
All	60	13.3	11.7	1.6	5.6	0.29	0.52	3.1			
Strength test											
Practice	30	27.7	24.5	3.2	12.5	0.26	0.94	3.4			
Control	30	24.2	20.4	3.8	10.6	0.36	0.86	4.4	−0.6	1.27	−0.47
All	60	25.9	22.4	3.5	11.8	0.30	0.64	5.5			
Perforation test											
Practice	30	38.7	33.3	5.4	7.9	0.68	1.04	5.2			
Control	30	36.8	28.0	8.8	7.6	1.16	1.50	5.9	−3.4	1.83	−1.86
All	60	37.8	30.6	7.2	8.2	0.88	0.98	7.3			
Tracing path test											
Practice	30	76.5	78.6	−2.1	17.6	−0.12	1.57	−1.3			
Control	30	73.8	74.0	−0.2	21.7	−0.01	1.48	−0.1	−1.9	2.15	−0.88
All	60	75.2	76.3	−1.1	19.9	−0.06	1.10	−1.0			

practice and control groups (column 6) do not vary greatly in any of the tests, showing that the distributions of measures in the 2 groups were similar.

3. The gains expressed in units of the standard deviations on the first test show that the control group made larger gains than the practice group on the strength and perforation tests. Both groups made losses on the tracing path, that of the control group being smaller.

When total groups are considered the gain for the moving target test is 0.29 sigmas; strength test 0.30; perforation test 0.88; tracing path −0.06.

4. The statistical significance of the gains of 60 children (columns 8 and 9) is greatest for the perforation test, the gain being 7.3 times the sigma. It is next greatest for the strength test, the gain being 5.5 times the sigma; then for the moving target with 3.1; and finally for the tracing path with a negative 1.0. Thus the groups as a whole made significant gains in 3 of the 4 motor tests. For the small loss on the tracing path test the writer has no explanation.

5. Columns 10, 11 and 12 show that the differences in gains of the practice and control groups are not statistically significant on any of the 4 tests. The gain of the practice group on the moving target test was 0.6 ± 0.95 more than the gain of the control group. The gain of the practice group was 0.6 ± 1.27 less than the gain of the control group on the strength test; 3.4 ± 1.83 less on the perforation test; and the loss 1.9 ± 2.15 more on the tracing path test.

SUMMARY

The present paper reports a parallel study to the moving target test investigation on the effects of specific practice on the increase of motor skill. The 60 children in the target study were also given the strength, perforation and tracing path tests once during the period when the initial target tests were given, and again when the final target tests were given approximately three months later.

On the strength and perforation tests the increases in skill without specific practice as shown by the tests were comparable to increases on the target test either with or without specific practice; while on the tracing test slight losses were found. No important difference was found on any of the four tests between the gains of the group that was given weekly practice on the target test and the gains of the control group.

These results support the conclusions of the former paper that improvement in skill may result from factors other than specific practice, such as the influence of structural maturation and of general practice. Probably no one doubts that specific practice must at times be given to young children, but for what skills and under what conditions is as yet largely undetermined. The implication of the experimental findings of this and of the previous paper is that factors other than specific practice may account for much of the learning of young children.

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The Roentgenographic Appraisement of Skeletal Differentiation[1]

T. Wingate Todd

The significance of a qualitative study of growth

It is a well established fact that different parts of the body differentiate and mature at different periods of the life span. We know, for example, that the auditory ossicles and labyrinth are fully matured at birth, that the eyeballs and brain have almost reached adult size by five years, that the thymus and tonsils are at their greatest development and activity in childhood. The list might be indefinitely extended although along such lines we should but make generalizations without that directness of evaluation to which the method of study lends itself. It has been our good fortune during the past eighteen years to assemble a collection of human skeletons from known individuals for each of which it has been possible to secure the necessary data for a comprehensive study of growth and maturation, and of age changes in the remainder of the life span so far as these are set forth in the bones. This series has now reached the comparatively large total of eighteen hundred individuals including more than two hundred children and young people. In addition the roentgenographic study of a test sample of over one thousand children gives us opportunity to check the observations made both by the X-ray and by dissection or maceration on our skeletons. Hence it is my object in this communication to direct attention to the principles of differentiation and maturation in the skeleton with special reference to those areas which we have studied most intensively during the past four years, namely the knee, the hand, and the elbow.

In a previous article I have discussed the problem of comparative youth and have given briefly our conclusions that although the chronological record varies with the order, family or genus of mammal chosen for investigation, the time relationships are sufficiently precise within the selected group to make comparisons possible of sequence and rate of maturation (1). I have also, in another paper, presented the principles of epiphysial differentiation and union which hold good for all parts of the maturing skeleton (2). It is now possible to inquire more deeply into the specific features of maturation and the time-linkages involved.

Since the ossified parts of the living skeleton alone are radio-opaque, it is

[1] This is the third of a series of studies on Comparative Youth from the Hamann Museum, Laboratory of Anatomy, Western Reserve University, Cleveland, Ohio, prepared for the White House Conference.

practicable to study simply the bony differentiation. The cartilaginous skeleton remains a sealed question. In the dead this difference is at least partially resolved for both cartilage and muscle become radio-opaque from coagulation in embalming. The possibility of dissection finally removes all difficulties of interpretation. A combined study of skeletons and living children then opens up great opportunities for enlarging our knowledge and understanding of the changes undergone by the skeleton during the period before adulthood is attained.

It is essential, in the first place, to recognize that an epiphysis is not to be construed as a bony cap. It is a cartilaginous structure which ossifies completely, partially or not at all. If it ossifies in part only as at the symphysis pubis, the lateral end of the clavicle and the upper and lower surfaces of the vertebral bodies, the remaining cartilage is absorbed but the bony fragments of epiphysis and the adjacent surface of the shaft undergo the same stages in differentiation and maturation as if the epiphysial ossification were complete.

My colleague Doctor N. W. Ingalls has shown in a very thorough investigation of the growing femur that the form and proportions of the articular ends, characteristic of the adult, are already exhibited in the cartilaginous ends at birth (3). And Graves has demonstrated the preformation of convex, straight and concave types of the vertebral border of the scapula in the foetal cartilaginous state (4). In the epiphysial unit then, growth merely increases dimensions.

For the shaft there is another story: proportions change with growth as well as dimensions. So long as we rely upon dimensions of the skeleton in general or of any unit in particular as our standard of measurement and time-linkage, as we have been accustomed to do, so long will we be baffled or hampered in our estimates. I do not mean to infer that dimensional measurements, quantitative though they be, ought to be discarded, ignored or minimized in value. It is important to realize that quantitative measures involving growth are subject to influences which do not affect the qualitative standards of differentiation. As a rule, if the organism is handicapped, the disability shows itself in dimensional stunting rather than in retardation of differentiation. There are far more people of small stature in the world than there are people of inhibited maturity. Whether we are tall or short we tend to progress toward maturity at the same rate. Edith Boyd has recently shown that an excusable error in dimensional measurement may easily reach the value equivalent to six months' growth (5). In laying stress upon the advantages of recording progress in the qualitative terms of differentiation we seek merely to eliminate one disturbing factor from our calculations and to add another check upon the accuracy of our determinations.

GENERAL METHOD OF STUDY

In addition to a rather full study of bodily dimensions, including weight, and an examination of muscular power each child of our sample group, numbering approximately one thou-

sand, was roentgenographed. The roentgenograms were antero-posterior and lateral of hand, elbow, knee and foot, with antero-posterior only of hip and shoulder. The total exposure is less than that to which a patient is subjected in a regular hospital examination. Finding that we never encountered even a slight malaise or disturbance we added a lateral of the skull to the later examinations.

The children returned for re-examination at intervals of several months so that in the course of two years we had frequently two and less often three studies of each child.

In order to forfend any obvious interference with the ease of establishing standards of age-relationship in bony differentiation we divided our living children series into groups by sex and color and investigated each group separately. Long experience of research on the skeleton led us to suspect that the white children would be far less irregular in differentiation than the negroes and that the boys would show greater uniformity than the girls. The sequel proved our hypothesis correct. We made no effort to distinguish between different nationalities or localities of birth and upbringing though we later found certain small divergencies apparently linked, probably indirectly, with these factors.

We then still further subdivided our sex and stock groups into series by age into units of six months and checked the birth records. Utilizing those roentgenographic records only of children the register of whose birth we had actually seen on the City Hall records, we arranged the roentgenograms in order of differentiation, working upon one of our six areas at a time, and chose that child as our standard for the period nearest to mean value in roentgenographic differentiation, in stature and in weight. Comparing our sequential standards we could then interpolate the remaining roentgenographic records. Having thus drawn up an atlas of differentiation we discarded all our previous work and, upon the basis of our roentgenographic atlas, gave each child an age valuation in years and months. This technique, first carried out for male whites, was repeated upon female whites, male negroes, female negroes and lastly upon undernourished children from the Children's Fresh Air Camp and the Cleveland Nutrition Clinic. As, one by one, our skeletal areas were studied in completion we made a comparison of the age valuations for each on every child and checked these against chronological age, height age, and weight age. The results were so gratifying that we immediately put the method into practice in the numerous child examinations which the city requests of us and we have no reason to regret this step.

The determinations in each stage of the work have not depended upon the observations of a single individual. Between four and eight trained observers have independently gone through every detail of the investigation. The number of workers employed has naturally depended upon funds available and willingness to cooperate. We have allowed no record to pass without at least four independent judgments and one common consultation and discussion thereafter.

So assiduous a study is not completed speedily. For four years we have been continuously at work and so far have completed our survey of knee, hand and elbow. Shoulder, hip and foot are in various stages of progress and at least another year's study will be needed before these are ready for publication.

Confining our attention to the areas already thoroughly studied it is possible to survey briefly the principles of differential epiphysial maturation and their time relationships.

THE PROBLEM OF INITIAL OSSIFICATION

Numerous studies have been made of the inception of ossification in carpal bones and upon them have been based attempts at definition of time-linkage. That there is value in this method there is no doubt. Without seeking to present an adequate survey or bibliography of the work which is largely based upon Pryor's pioneer investigations one might refer to Miss Sawtell's recent work in which she extended the method to include lower end of radius and ulna (6, 7). Doctor Sawtell indeed checked the method against the qualitative study of differential maturation which we have developed and found her results about equally dependable by both methods. But since the children at her disposal greatly diminished in number soon after the date when our method becomes available we take great encouragement from her positive findings even though they seemed to her equivocal.

It should be realized that the individual variability in appearance of ossification of the several carpal bones should not be set down to a "natural" variability until a thorough investigation has been made of possible influences which may affect the date of inception. Perhaps this assumption of natural variability may have been one of the most stultifying conceptions in all work of this character. We have noted evidence in our records of the passage through the system of some devastating influence of temporary character which appears to have held up the progress of maturation and from which the skeleton is in process of recovery. Concerning this we shall have much more to recount at a later date.

In practice we are not concerned with the actual date at which osseous material is first precipitated in any cartilaginous area nor are we inclined to take into account the more or less symmetrical extension of this ossific center until the later stages are reached where final delineation of ultimate outlines is foreshadowed.

Since no epiphyseal ossifications have reached the stage when they can be profitably used as qualitative age determiners until the sixth year of life, at least in boys, we shall commence the account of observations with the fifth birthday.

To avoid confusion by the injection into the problem at this stage of the modifying influences of sex and race, we shall confine the following account to the male white series. It is not an easy task to examine the host of available roentgenograms, bearing all possible features in mind, to evaluate these, identify them on the chosen group of unimpeachable age-record and establish their distribution. If the reader be inclined to cavil at our

results, let him bear in mind that each feature herein described has been searched for by half a dozen different investigators on twelve hundred roentgenograms, an analysis occupying more than three years of steady work. Our simple method of statement is purely in the reader's interest.

Should the reader attempt to use this preliminary account as a guide for age-identification he must be warned that the greatest difficulty will be encountered between seven and nine years, more especially in hand and elbow than in knee. During these years the indicators are peculiarly delicate and hence require more experience and judgment for correct interpretation than at other ages before or after.

After thirteen years and a half we enter upon another phase of epiphysial study. No longer are we dependent upon differentiation of bony outline in the various epiphyses. There now begins the progressive pattern of union which makes much easier the identification of age. We are no longer seeking features of stages I to V inclusive of the maturation of epiphyses. We now look at specific areas for evidence of stages VI to IX (2). Consequently, after thirteen years and six months the dates at which these later stages may be expected alone are mentioned in this account.

PRINCIPLES OF BONY DIFFERENTIATION IN THE KNEE

At the knee we depend almost entirely upon bony differentiation of the epiphyses of femur and tibia for our standards. Since the patella commences to ossify erratically like the carpals and its inception occurs towards the fifth birthday in boys one may rule it out until much later. The upper epiphysis of fibula is of relatively little service until it is almost completely ossified, an event which does not occur until after the twelfth birthday.

Between five and five and a half years there is no great amount of ossification in either femoral or tibial epiphysis. In the femur the ossification scarcely advances beyond the dorsal line of the shaft. The lateral epicondyle shows more ossification than the medial.

The outline of the tibial ossification is much rounded with but a suggestion of the ultimate appearance of 2 condylar surfaces the medial of which shows some condensation into a white line. The backward extension, as in the femur, scarcely reaches the level of the dorsal line of the shaft.

In the following six months ossification of femoral epiphysis projects beyond and tibial ossification reaches the dorsal shaft projection line. Ossification of the medial femoral epicondyle is now progressing more rapidly than in the lateral. Tibial epiphysis ossification shows clear evidence of medial and lateral extensions and the medial condylar face is further etched in. A faint haze springs up along adjacent shaft surfaces of both bones.

Between six and six and a half years ossification has progressed considerably in both epiphyses. The lateral femoral epicondyle casts a shadow almost as far as the lateral angle of the shaft but medial epicondylar ossification lags behind but has a ragged

appearance. The tibial epiphysis begins to show indications of a lateral condylar surface. Both adjacent shaft surfaces maintain their slight haziness.

In the next six months again rapid progress in ossification has taken place in both epiphyses. The medial femoral epicondyle is still ragged. Its ossification however now almost reaches the line through the adductor tubercle. The limiting angles of ossification nearest the shaft on both epiphyses are somewhat squared. The shaft haze remains.

Between seven and seven and a half years the shaft hazes have become quite widespread from the surface. In both epiphyses ossification has extended beyond the bevelled contours of the shaft. In femur the intercondyloid notch is still shallow and in tibia the lateral condylar surface is a little more clearly indicated.

Six months later this lateral tibial condyle is distinctly foreshadowed. The haze on both shaft surfaces is maintained.

Between eight and eight and a half years the tibial ossification for the lateral tuberosity extends like a long tongue almost as far as the shaft line: both lateral condyle and spines show progress. On the femur the downward extension of medial epicondyle and the intercondyloid notch are both better marked. The shaft-haze begins to diminish.

In the succeeding six months the shaft haze has given place to a white line of delineation and a similar line, maturing during the last few periods, is now complete on the adjacent epiphyseal surface.

Both diaphyso-epiphysial gaps are broad and trumpet-shaped at both extremities.

Between nine and nine and a half years there is but little change from the features of the previous period. The adjacent surfaces of shaft and epiphysis parallel each other more closely and the trumpet-shaped extremities of the gap are encroached upon by an angulation towards the shaft of the bony epiphyses. In addition the lateral tibial condyle shows a building up of its periphery.

In the next six months the medial and lateral margins of the femoral epiphysis lose their rounded outline and begin to take on the adult rugged contours. The intercondyloid notch is also more significantly adult. Squaring of periphery of both tibial condyles proceeds apace.

Between ten and ten and a half years the medial and lateral angles of the shaft surfaces of both bones show an erosion, blunting and even rendering them concave. The trochlear extension of the femoral epiphysis shows a faint upwardly directed beak.

In the following six months the trumpet-shaped extremities of the epiphysial gaps are lost through extension towards the shaft of the bony epiphyses which are clearly now beginning to develop peripheral rims. This is better marked in femur than in tibia. The peripheral contours of both epiphyses take on more definite adult characters.

Between eleven and eleven and a half years the diaphyso-epiphysial gap is distinctly narrowed. This is more easily seen in the tibia because there is less overlap of shadows. The double

contour of the articular surface of patella now comes into being.

In the next six months the tibial spines are clearly developed in bone but have not yet sharp outlines. The epiphysial peripheral margins are almost completely adult in contour and the condylar outlines almost sharp though the bony epiphyses do not as yet fit like caps overlapping the shafts.

Between twelve and twelve and a half years there is no marked change.

In the succeeding six months the trochlear diaphyso-epiphysial gap is filled and the epiphysial peripheries almost cover the shafts.

Between thirteen and thirteen and a half years the tibial tubercle has ossified as a downwardly directed tongue of bone, the tibial spines form sharply outlined minarets and the epiphyses of both bones surround the shaft peripheries as with a claw.

Beyond thirteen years and a half the knee epiphyses are of service only at intervals.

Between fourteen and a half and fifteen years the tibia enters on stage VI with narrowing of the epiphysial gap.

Between fifteen and fifteen and a half years stage VI is apparent in femur and in fibula.

Between sixteen and sixteen and a half years the epiphysial gap in the tibia is so reduced that the roentgenogram is apt to give misleading and fallacious evidence of commencing union but the area has not really yet reached stage VII where union begins.

Only the most careful exmination of the roentgenogram of seventeen to seventeen and a half years will indicate to the experienced observer that union is incomplete in femur, tibia or fibula. The naked bone shows no surface indication of union though it would be an untenable position to hold that nowhere in the depths of the gap is there any fusion, at least in the tibia.

Between eighteen and nineteen years both stage VIII of recent, and stage IX of perfected union are passed through in all 3 bones.

PRINCIPLES OF DIFFERENTIATION IN THE HAND

In the knee the massive epiphyses of femur and tibia carry so much of the information applicable to a study of time-linkage in differentiation that one is apt to overlook, on that account, the significant information to be obtained from the shafts. In the hand however the shafts and epiphyses of the long bones and the bony maturation of the carpals all play their part. Phalanges and ulna are of little value for this investigation. The radius, on the contrary, is of paramount importance. Metacarpals follow close behind the radius. And the carpals also give us very definite information once their apparent vulnerability to retarding influences is recognized and discounted.

Shortly before the sixth birthday the bases of metacarpals II and III foreshadow their adult outline. The saddle-shaped contour of the second is definitely attained although the clear white line which marks its ultimate differentiation does not appear till almost eighteen months later. The bony invasion of radial epiphysis is not far advanced at this stage though an oblique line marking the border be-

tween palmar and distal surfaces is evident.

Between six and six and a half years the epiphyses of metacarpals II and III, sometimes of IV but never of V are so far penetrated by bone that on the roentgenogram they appear as D-shaped shadows with the flat outline next the shaft.

In the succeeding six months the process spreads to the head of metacarpal V and includes IV if this did not appear before.

Between seven and seven and a half years the white line of compacta demarcating the saddle-shaped base of metacarpal II makes its appearance.

In the succeeding six months attention is diverted to the radius for its epiphysis shows ossification of the styloid process. The adjacent surface of shaft presents a billowed outline picked out in the typical thin white line of compacta.

Between eight and eight and a half years the carpus begins to contribute to our study in the white line marking the facet on os capitatum for articulation with metacarpal II.

In the following six months ossification springs up with sudden rapidity in the radial epiphysis extending medially as the "ulnar tongue."

Between nine and nine and a half years the bony heads of metacarpals II, III, IV possess a clearly defined squared outline like those of the adult.

In the next six months a radial extension of ossification occurs in the radial epiphysis in the angle next the shaft.

Between ten and ten and a half years there is often a completion of the adult contour of the medial side of the fifth metacarpal bony head and a billowing of the ulnar shaft. Both features may however appear earlier than this date.

In the following six months the bony outline for the radial aspect of metacarpal heads II, III, IV, V makes its appearance.

Between eleven and eleven and a half years identification of specific characteristics in the hand becomes singularly difficult. There is indeed an expansion of the bony epiphysis of the radius laterally on the side adjacent to the shaft and a sudden development of adult outline in the two multangulars.

In the next six months the ulnar tongue of the radial epiphysis shows indications of the recurvation characteristic of a year later. The bony epiphysis for the first phalanx of the index finger protrudes beyond the line of the shaft on the lateral or radial aspect.

The hand has now reached a stage when it gives but little direct indication of the progress of time. Between twelve and twelve and a half years there is no characteristic feature although it is true that the inclination towards recurvation of the ulnar tongue in claw-like form over the shaft of the radius is strengthened.

In the succeeding six months recurvation of the ulnar tongue has progressed to the form of a small beak which is further developed between thirteen and thirteen and a half years at which date the later phases of preparation for union of epiphyses in phalanges and metacarpals begin to make their appearance.

After thirteen and a half years, as

in the knee, we change our method of analysis and look for stages VI to IX.

Between fourteen and fourteen and a half years the epiphysial gaps in phalanges and metacarpals commence to diminish.

This narrowing continues during the next twelve months and already the terminal phalanges have reached stage VIII, of recent union, soon after fifteen years.

Between fifteen and a half and sixteen years all the phalanges have reached stage IX (perfected union) and the metacarpals are in stage VII (commencing union) if not already in stage VIII. The gaps in radius and ulna now begin to shrink.

After sixteen years the metacarpals have followed the phalanges into perfected union (stage IX) and the roentgenographic shadows of radius and ulna are overlapping so that both diaphyso-epiphysial planes seem broken up though comparison with the naked bones shows that this is not really so.

Even between seventeen and seventeen and a half years however the roentgenogram, carefully studied, will demonstrate the complete patency of both radial and ulnar gaps. A year later these epiphysis have reached the condition of recent union (stage VIII).

PRINCIPLES OF DIFFERENTIATION AT THE ELBOW

The elbow gave us far more trouble than either knee or hand and at first it seemed as though we would be baffled for of all the diaphyso-epiphysial lines that of the capitulum alone appeared to be helpful. Our final identifications are indeed largely influenced by the indications of that area. Radius head is little more than a scale. Olecranon and medial epicondyle have little specific character. Trochlear ossification is very various in type since the amount of humerus developed in this epiphysis is quite erratic. Sometimes there is a sizeable epiphysis: in other individuals it is but a scale smaller than that for the radial head.

Our interpretations of capitulum are greatly strengthened however by differentiation of the adjacent shaft. Hence, in elbow, our observations, unlike those of hand and knee, are just as closely related to shaft as to epiphysis.

Between five and five and a half years there is incomplete ossification in the ends of all 3 shafts. Consequently the roentgenographic shadows appear to indicate imperfect formation. The actual skeletal formation is, of course, complete but, being largely cartilage, is not radio-opaque.

The ulna shadow shows a shallow greater sigmoid fossa of which the coronary beak is not at all well marked so that it is seen with difficulty on the antero-posterior view and scarcely projects at all on either medial or lateral side of the shadow. The olecranon process shows but the faintest indication of a billowing. It is indeed a mere ripple confined to the shaft surface of which the postero-superior area is not yet completely ossified.

On the humerus the capitular epiphysis is considerably ossified but has an irregular margin facing the shaft surface on which can be seen a faint

ripple of billowing. There is only slight angularity between the shaft surfaces which support medial epicondyle and trochlea respectively.

There is no ripple as yet on the surface of the radial shaft.

Six months later the coronoid beak is visible both medially and laterally. The ossification in postero-superior area of olecranon and rippling of subepiphysial shaft surface of olecranon are both better marked. The radius shaft and capitular surface of humerus both now show distinct rippling and the shaft angle between medial epicondyle and trochlea is better defined. It must be realised however that there are pronounced individual differences in the degree of ripple and often it is scarcely visible.

Between six and six and a half years the features of the previous period become intensified. The bony olecranon is more massive and squarer in outline on the lateral roentgenogram. The ossific nodule in the humeral capitulum begins to show a saddle-shaped outline. It is true that there is ossification in the epiphyses of radial head and medial epicondyle of humerus and that the date of appearance of these centers is more uniform in elbow than in hand. Nevertheless we shall make but incidental reference to such precipitations as we are by no means convinced of the reliability of their age relationship.

During the following six months there are no specific characteristics. There is merely extension of the features demonstrated in the previous period.

Between seven and seven and a half years the ossification center in the capitular epiphysis throws out a bony tongue towards the trochlea. This tongue was suggested just after the sixth birthday but at that earlier date the shaft angle between surfaces supporting medial epicondyle and trochlea was not nearly so advanced as it is at this time.

In the succeeding six months bony delineation has reached the surface of the cartilage between medial epicondyle and trochlea although the outline is not yet as sharp as it will eventually be. There is also an extension of rippling or light billowing from capitular shaft surface on to that for the trochlea. The capitular epiphysis ossification begins to spread backwards erratically.

Between eight and eight and a half years the trochlear ossification is extended and the beak of shaft between trochlea and medial epicondyle is further delineated. The backward extension of capitular epiphysial ossification is still quite erratic.

In the following six months the outline of humeral shaft supporting the medial epicondyle becomes distinctly concave. Both in that epiphysis and in the capitulum there is distinct ossific extension.

Between nine and nine and a half years no fresh features are developed though progress can be estimated by comparison with the provisional atlas of stages.

In the succeeding six months the distal humeral shaft shows distinct growth so that the capitulum seems mounted on a pedestal which is particularly developing on its lateral aspect. The supporting surface for medial epicondyle begins to show rippling.

Between ten and ten and a half years the building out of the lateral area in humeral shaft continues while the ossification of the capitulum overlying it is also extended to approach the lateral margin of the shaft. The elbow makes little progress about this time.

Six months later the capitular ossification develops a proximally directed beak at its lateral extremity. This is projected like a claw shaft-wards and precedes the bevelling of the outer angle of the humerus. Erratic ossification begins in the trochlea and olecranon.

Between eleven and elven and a half years there is progress in ossification of trochlea and olecranon but one can claim only as characteristics of the period, an increasing angulation at distal lateral area of humeral shaft, of the capitular epiphysis in the same region, and of the proximal though not yet the distal extremity of the ossific nodule for medial epicondyle. As an age indicator the elbow is already becoming less useful.

In the next six months the shaft outlines beneath capitulum and trochlea become more uniform in slope. This does not necessarily mean that the capitular plane is built up to that of the trochlea: it may still be behind but the general inclination is almost identical on both. The capitular ossification projects backwards like the tail of a comma and there is an increasing parallelism in the adjacent surfaces of shaft and epiphysis. If the olecranon center has hitherto failed to appear it is present now.

Between twelve and thirteen years the several beaks and angulations already mentioned continue their differentiation. In the earlier six months the diaphyso-epiphysial plane under the capitulum becomes sigmoid in the antero-posterior roentgenogram and in the latter six months the capitular beak projects along the lateral aspect of the shaft.

Between thirteen and thirteen and a half years the sub-capitular plane begins to narrow and, in this respect, leaps ahead of all the others at the elbow. Thereafter we are concerned with the epiphysial closure pattern rather than a progress of ossific differentiation.

Already at fourteen to fourteen and a half years there may be commencing union (stage VII) of the distal epiphysis of the humerus, trochlear and capitular ossifications having fused. The union is perfected during the following six months which is marked also by shrinkage in the gap between the radius and its head but not in that between humeral shaft and medial epicondyle. Not only is the olecranon gap reduced but union has commenced.

Between fifteen and fifteen and a half years union has commenced in the diaphyso-epiphysial junction of the radial head and the gap beneath the medial epicondyle is reduced. Olecranon is in the stage of recent union (VIII) and in distal humeral epiphysis fusion is perfected.

After the sixteenth birthday fusion is complete in all elbow epiphyses and the area passes out of the series of age indicators.

Dull and colorless as such an account of epiphysial differentiation must necessarily be, it is important to

realize the stages by which progress in skeletal maturation occurs. The vexed questions of sex and race can find no place in this description which is intended solely as a summary of illustrative material against which roentgenographic records may be checked. To further this object we purpose to draw up detailed accounts with each of which there will be an atlas of carefully reproduced roentgenographic bony outlines to form a seal of definiteness upon our observations.

SUMMARY

1. A qualitative study of growth is called for by the fact that different organs mature each in its own time and manner. Even in such a uniform system as the skeleton, the various parts attain adult characters at very different ages.

2. Although the cartilage precursors of the articular extremities of the various bones differ in size but very little in proportions from the bony extremities of the adult, the penetration of the cartilage by ossification presents so definite a sequence and pattern that it can be utilized as an age indicator.

It is true that disturbance, especially of a pathological character, may modify pattern, sequence and date. The ravages accompanying this disturbance can usually be clearly identified.

3. The samples of male white children at our disposal have been used for this purpose upon the hypothesis, now substantiated, that there is less variation resulting from non-pathological influences among them than among females or negroes. In a later paper the problems of sex and race will be discussed.

4. The reader is warned against the assumption of a "natural" variability in the absence of positive evidence.

5. In this study the date of earliest precipitation of bone into the cartilage, whether of carpals or epiphyses, is not valued highly because that stage of differentiation is singularly vulnerable to influences which delay the characteristic features or distort the evidence.

6. The method of epiphysial and diaphysial differentiation is applicable to the skeleton under thirteen and a half years (in the male). Thereafter it is the closure pattern to which attention must be devoted.

7. In the knee the epiphyses of femur and tibia give most of the information but their underlying shafts present some useful data. Patella and fibula are of less account.

8. In the hand lower epiphysis of radius, the metacarpals and their epiphyses and to a less extent carpals, phalanges and ulna enter into the picture. Because of the frequency of disorder in carpal ossification one must not rely upon their bony etching unless the data presented are confirmed by radius and metacarpals.

9. In the elbow capitular epiphysis of humerus and the shaft area underlying it carry most of the data useful for our purpose. The availability of elbow as an age-determinant is much more restricted in time than the knee and hand.

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The Development of Right-handed Skill in the Left-handed Child

JOSEPH E. MORSH

IN TEACHING the older child to use the non-preferred hand one is confronted by three main problems. The "set" due to habit and earlier training must be broken down; the antagonistic prejudices of parents and teachers must be combatted; and a strong attitude of self-motivation must be built up. Of these three problems the last is probably the most important and an attempt at its solution is the chief concern of this article.

The experiment was undertaken to see whether it were possible to take children into the laboratory and without seriously interfering with their everyday activities, form in them a desire to learn to use their non-preferred hands. The fact that they came to the laboratory, without monetary or other inducement, during the period of the experiment showed that their interest was maintained and the results would seem to justify the method employed.

The skill which was to be developed was writing with the right hand. The method was, briefly, to teach writing with the right hand where the left hand had formerly been used exclusively, without directing attention to the act of writing. In other words, the main point in the experiment was to get the attention of the children away from the activity, as much as possible so that they would gradually acquire a new right-handed habit without realizing that a new habit was being formed.

The subjects used for the experiment were two girls whom we shall designate as B and E. E was twelve years old on July 15, 1929, and was a pupil of the eighth grade. B was a fourth grade pupil and was nine on August 22, 1919. B's score with the Stanford Revision of the Binet-Simon test indicated an intelligence quotient of 100 plus, while E's intelligence quotient was 123 plus. With B, Myer's Mental Measure was used as a check, as the Binet-Simon was given when B was tired. It was found, however, that the latter test agreed with the Binet-Simon very closely. It is worth noting that a remarkable correspondence was found between the intelligence quotients obtained from these tests given in the laboratory and those supplied by the teachers in the public school which the girls attend. Both subjects, as shown by these results, are of normal intelligence while E probably has superior intellectual capacity.

The history of left-handedness in the families of both girls is interesting. E's father and paternal grandfather were left-handed. Her maternal uncle was left-handed as a child but was forcibly prevented from using his

left hand and became a very proficient ambidextrous writer. B's maternal aunt and uncle are left-handed.

The experiment began on November 2, 1929 and continued until March 1, 1930, sessions being held weekly until the Christmas holidays and semi-monthly after that time. In a general way it may be divided into three parts: first, tests and observations to ascertain some of the abilities of the subjects (especially manual abilities) with the specific aim of finding out the "degree of handedness;" second, preparatory exercises involving varying amounts of manual-visual coördination; and third, exercises for practise in the activity taught, in this case, writing.

DIAGNOSTIC TESTS

The term "left-handed" is used rather loosely in everyday parlance to designate an individual who uses the left hand in performing some major activities. The word left-handed has, however, no absolute value such as, for instance, the word blind. To be blind is to be devoid of eyesight but to be left-handed is not to be devoid of use of the right hand. To say that a person is left-handed, then, is not to convey much scientific information about him unless we are given an idea as to the extent of the left-handedness. Thus there may be vast differences in the manual habits of so-called left-handed individuals. The first part of the experiment, as before mentioned, was designed primarily to find out what was being dealt with in the matter of handedness, that is, just how much left-handed the subjects were. For this purpose 2 kinds of tests were used. The first group consisted of a number of unimanual and bimanual activities most of which involved gross motor coördination, though a few, such as writing, drawing and painting necessitated finer, more precise coördination.

Table 1 indicates the results of the first group of diagnostic tests. It will be noted that while both subjects used

TABLE 1

Hand used in major activity

ACTIVITY	E	B
Drawing on paper or blackboard	Left	Left
Ruling lines	Left	Left
Painting	Left	Left
Cutting with scissors	Left	Left
Peeling fruit with knife	Left	Left
Peeling fruit by hand	Left	Left
Buttoning and unbuttoning	Left	Left
Holding tooth-brush	Left	Left
Placing objects on table	Left	Left
Pushing needle	Left	Left
Threading needle	Right	Left
Picking up or carrying objects	Right	Left
Receiving or handing objects	Right	Left
Ironing	Right	Left
Throwing	Right	Left
Wiping and dusting	Either	Left
Using knife, spoon and glass	Right	Left
Using fork (when knife is held)	Left	Right
Combing hair	Both	Both

their hands in an identical fashion in a majority of the activities they differed materially in some other activities. It would appear from the observation of these common operations that B was more left-handed than E.

With both subjects the left thumb is dominant, and a crude test seemed to indicate that the hearing in their left

ears was better than in their right (the watch-tick test was used). Their eyes were tested with Ives Visual Acuity apparatus, a second test to check the results of the first being given. This test indicated quite conclusively that B's left eye was better than her right while the contrary was true of E, her right eye being superior.

Dunlap's steadiness tester was used. Precision and coördination in tracing was also tested, by means of the Johnson coördination test. A complete description and the method of employing this test may be found in Johnson (2).

A summary of the results of these more exact tests is given in table 2. It is interesting to note that E's right

TABLE 2

Scores in tests of motor control

TESTS	E		B	
	Right hand	Left hand	Right hand	Left hand
Strength of grip (Best of 3 trials in kgm.)....	22.25	17.75	13.25	16.0
Speed of tapping				
Simple—one plate				
Average of 5 trials, 30 seconds each.....	148	155	118.6	115.6
Complicated—two plates				
Average of 2 trials, 30 seconds each.....	39–44	51–48	40.5–44	52–43
Totals for each hand.....	83	99	84.5	95
Average of 2 trials, 1 minute each.....	90–91	109–109	79–84.5	91–82
Totals for each hand.....	181	118	163.5	173
Steadiness of hand				
Hole 5—contacts.....			11	10
Hole 4—contacts.....		8		
Hole 3—contacts.....	9			
Precision in aiming				
Average error in mm.....	8.3	10.2	10.3	11.9
Coordination in tracing				
Contacts in simple test.....	0	1	2	0
Contacts in intermediate test.....	9	2	14	5
Contacts in difficult test.....	66	35	93	37
Total contacts.....	75	38	109	42

The second group of tests in this part of the experiment were for the purpose of building up a more complete diagnosis of the extent or "trend" of left-handedness and the capacities of the subjects. Strength of grip, speed of tapping (simple and complicated), steadiness of hand and precision in aiming were all tested with the apparatus and after the manner described by Whipple (4) with the exception that

hand was considerably stronger than her left. This fact is probably accounted for when it is remembered that she used her right hand in carrying objects. In the simple tapping B was better with her right hand but in the complicated form of the test when she tapped on two plates alternately her left hand was superior. E, however, was consistently left-handed in tapping. The subjects differed, too, in steadi-

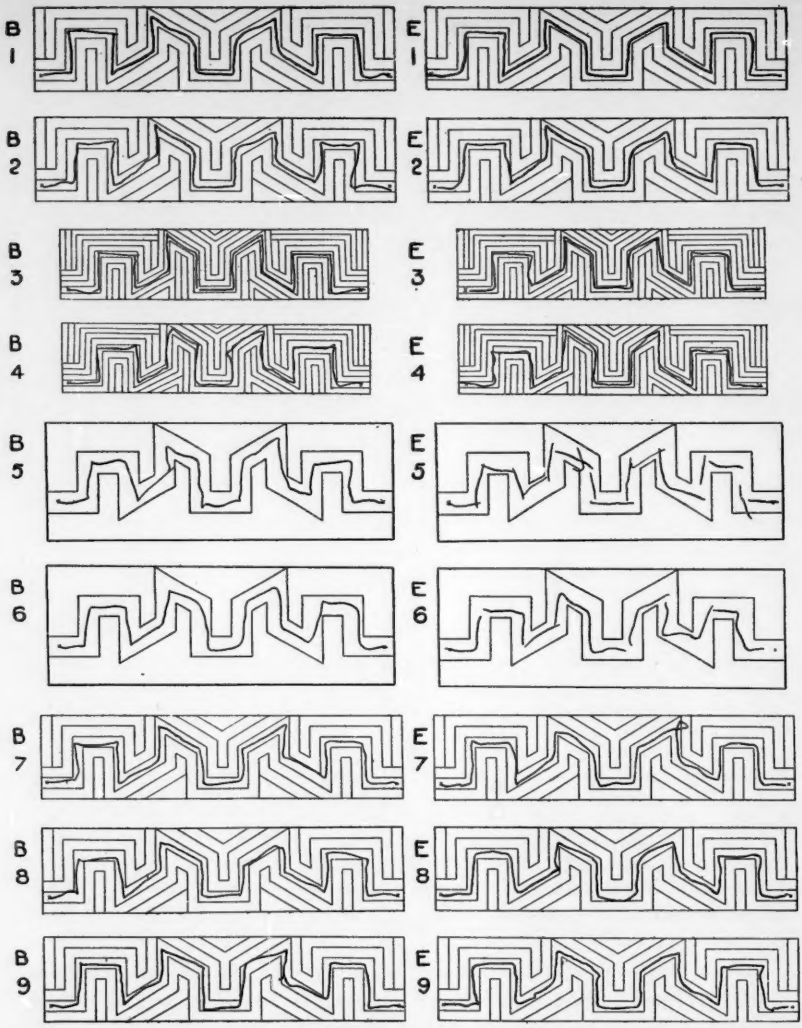

FIG. 1. COÖRDINATION IN TRACING

SUBJECT B				TEST	SUBJECT E			
Number	Date	Hand	Contacts		Number	Date	Hand	Contacts
B1	November 9	L	1	Intermediate	E1	November 9	L	0
B2	November 9	R	2	Intermediate	E2	November 9	R	2
B3	November 9	L	5	Difficult	E3	November 9	L	5
B4	November 9	R	15	Difficult	E4	November 9	R	9
B5	November 16	R	1	Simple	E5	November 16	R	2
B6	November 23	R	0	Simple	E6	November 23	R	0
B7	November 30	R	1	Intermediate	E7	November 30	R	2
B8	December 7	R	3	Intermediate	E8	December 7	R	2
B9	December 14	R	2	Intermediate	E9	December 14	R	0

ness. In this test the score is given for the smallest opening in which less than 12 contacts were made. B had slightly better control with her left than with her right hand while E was much better with her right. In the aiming test both girls showed superior coördination with their right hands.

In the Johnson coördination test both subjects showed a preference for the left hand, B favoring the left more markedly than E. This left-handed preference is clearly indicated in figure 1. B1, B3, E1 and E3 are average strips traced by subjects with their left hands. B2, B4, E2 and E4 show right hand performance on the same day. See legend to figure 1.

PREPARATORY EXERCISES

Although, strictly speaking, the first part of the experiment was preparatory as well as diagnostic, the second part had a more direct bearing on the subject in hand, that is, it paved the way for the writing itself.

To teach the fundamental strokes of writing Johnson coördination test blanks were used. The following instructions were given:

"Instead of drawing a continuous line as you did before (these were blanks of the test that had been used in the diagnostic work already mentioned) draw straight strokes but try to avoid touching the black lines. You may lift your pencil slightly from the paper at the end of each stroke and it does not matter if one stroke does not quite meet another one that you have drawn or crosses it a little bit. I shall time you but the time it takes is not so important as to draw nice straight lines and to avoid touching the black lines. Ready. Go!"

Subjects were instructed to hold their pencils in their right hands and use their left hands to steady the paper. No metronome was used.

TABLE 3

Precision in tracing

DATE	NUMBER AND KIND OF TEST SHEETS		TOTAL CONTACTS			
			B		E	
			Simple	Intermediate	Simple	Intermediate
November 16	5 Simple		3		10	
November 23	5 Simple		1		10	
November 30	3 Simple	2 Intermediate	2	16	1	30
December 7	3 Simple	2 Intermediate	3	42	0	12
December 14	3 Simple	2 Intermediate	1	23	1	6

Table 3 gives a summary of the results of the practise in precision in tracing. The strips from 5 to 9 inclusive in figure 1 are average strips taken from the last sheet done each day. With few exceptions, the contacts steadily decrease and the lines were drawn with greater confidence and rapidity, until the exercise was discontinued on December 14.

As it was thought that some activity involving grosser coördination might assist directly in the development of the finer coördination required

TABLE 4
Scores in target test

DATE	HAND	B	E
November 23	L	82	54
November 23	R	27	93
November 30	R	66	92
December 7	R	70	117
December 14	R	66	117
January 11	R	104	130
January 25	R	88	156
February 1	R	100	108
February 15	R	70	96
February 15	R	84	75
March 1	R	82	146

developed here. It will be remembered from the diagnostic tests that for E the right hand was the preferred hand for throwing while B is left-handed in this activity. The darts were thrown in 5 series of 10 darts each from a distance of 10 feet, the 2 subjects and the experimenter taking turns. As the latter was right-handed, he used his left hand to make the scores somewhat comparable. On the first day the subjects used both hands and thereafter only their right hands. The results as

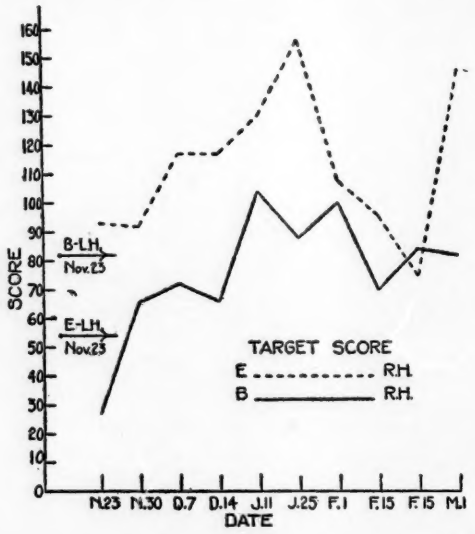

FIG. 2

in writing, as well as indirectly by stimulating subjects' interest in the whole procedure, the target test was used.

The subjects first threw darts on November 23 and continued this activity until the close of the experiment on March 1. An interesting point may be seen from table 4 are about what we would expect. Figure 2 gives a graphical representation of the target test scores.

The "pièce de resistance" of the whole experiment for the girls was Whipple's star tracing test, as this involved an activity which had never

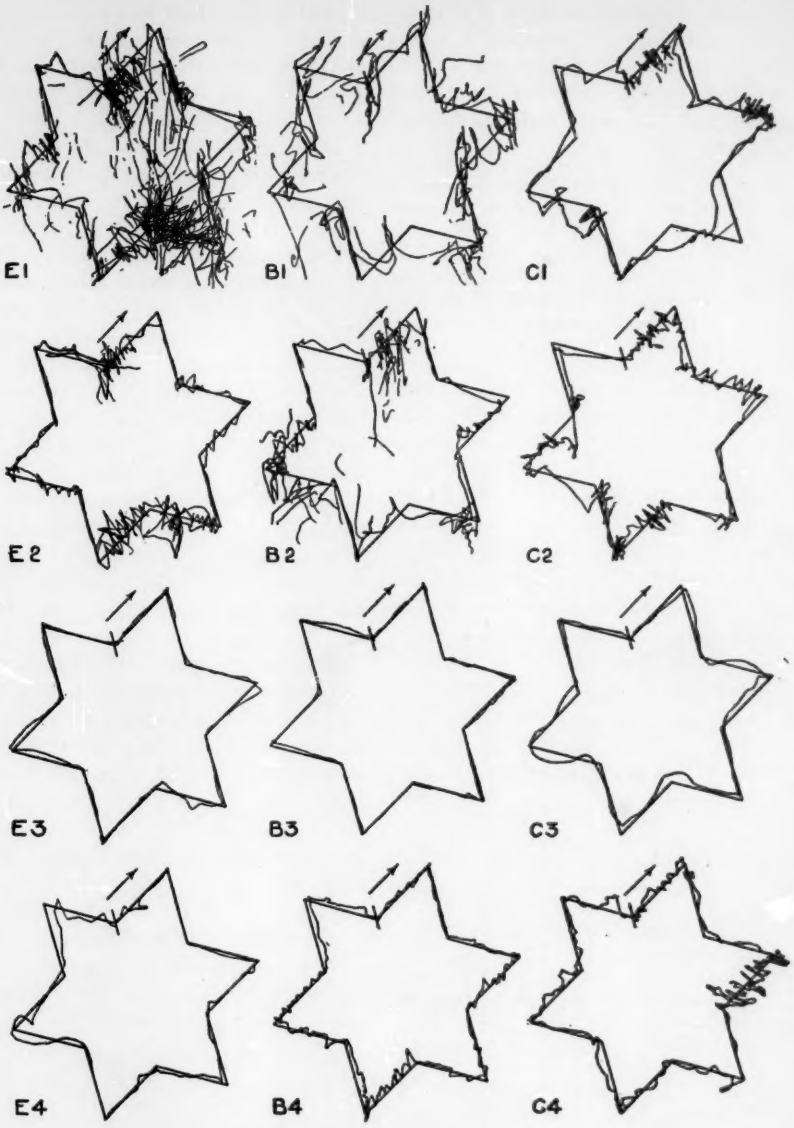

FIG. 3

before been attempted with either hand. When the subject was seated at the table with screen and mirror in position and the star fastened firmly with thumb tacks, the following instructions were given:

"Trace the outline of the star, starting in this direction (indicated by an arrow drawn by the experimenter). Work as rapidly as you can, but try to keep on the line. Don't stop to figure out what you ought to do, but keep your pencil going in some direction, and keep its point on the paper all the time."

The subjects used their right hands to trace all stars except the last one traced on March 1.

On November 9 it took E 11 minutes to trace here first star (E1, fig. 3), making so many errors that it was impossible to compute them by means of the stencil. A diagram of the stencil used in marking the stars and a description of the method of using it is given by Harold E. Israel (1). To quote from the article:

"The stencil is fitted over the star by means of the short guide lines at the points; then the traced outline is followed around from the starting point. Whenever any one of the boundaries of the zones parallel to the outline is crossed, an error is counted (naturally recrossings in the corrective direction are not counted). Thus a deviation beyond the extreme limits of the stencil in either direction from the outline will give an error score of three. Moreover, errors are added for each radial boundary, over one, which the tracing crosses before returning to within the "home" parallel zone. Allowing thus the width of two radial zones for the correction of a wrong motion, this feature penalizes hasty cutting across or carelessness . . . . . Lateral (parallel) zones are 3 mm. in width, and radial zones are 6 degrees."

It will be seen that this rigid system of marking allows a deviation from the outline of only one and one half millimeters less half the width of the pencil line for a traced star scored perfect.

E's second attempt (E2, fig. 3) took 3 minutes 58 seconds and also defied the experimenter's efforts to count the errors. B's first star (B1, fig. 3) took 3 minutes 25 seconds and she made approximately 160 errors. Her second effort (B2, fig. 3) required 2 minutes $57\frac{3}{5}$ seconds. The errors for this star were not computed. As the subjects tired the first day only 2 tracings were made. For 10 different days, at intervals from November 16 to March 1 inclusive, both subjects traced a set of 6 stars each day. E's fastest time for any one star was for her sixty-first star traced in $20\frac{3}{5}$ seconds on March 1 (E3, fig. 3) and her best star, the one with the fewest errors was her forty-first, the last one of the set she traced on January 25. It had 4 errors only. Her best average time for 6 stars was $24\frac{9}{10}$ seconds on March 1 and her lowest average error was $12\frac{5}{10}$ on January 25. The star traced on March 1 with her left hand, the last of the experiment, took $37\frac{3}{5}$ seconds and contained 31 errors (E4, fig. 3) indicating transfer of training but also showing marked superiority for the right hand at this stage in the activity.

B's fastest time for any one star was 26 seconds, this being the time for her twentieth star and the last of the set she traced on November 30. She traced her best star with fewest errors on February 15, this being the last star of the group traced that day and the fifty-sixth of her series. She made only

3 errors on this star. B's best average time was 36 seconds on December 7. (B4, fig. 3) was 1 minute 14⅔ seconds with 66 errors. The best star B

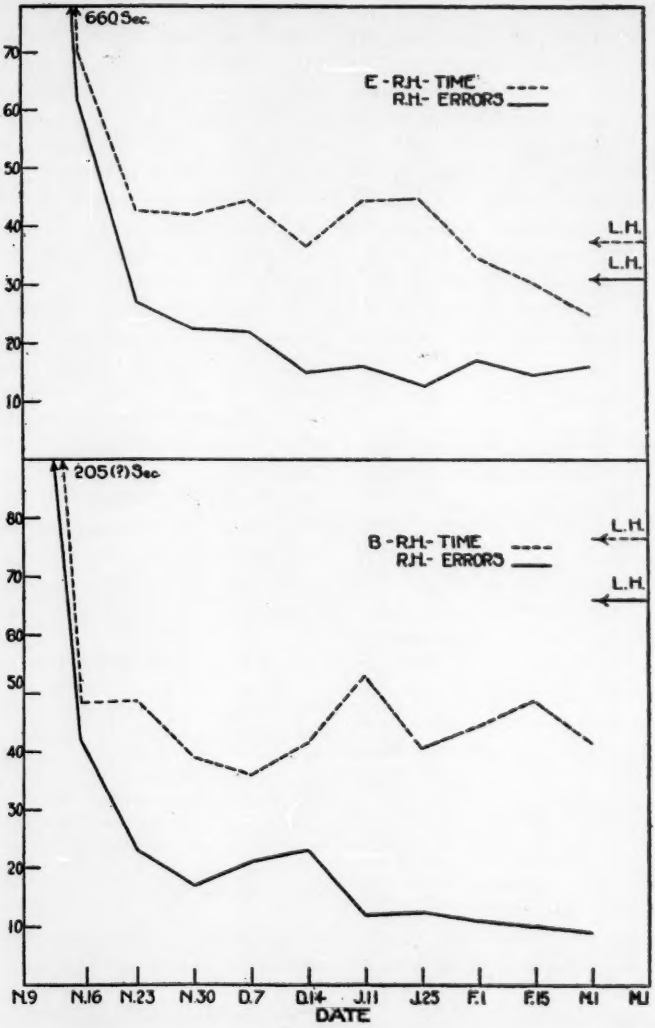

FIG. 4

Her lowest average error was 9 made on March 1. The time for her final star which she traced with her left hand traced on March 1 required 34⅔ seconds and contained 5 errors. It was the second of the group and the fifty-

eighth of the series (B3, fig. 3). This result indicates less transfer of training and even more superiority of right hand over left in this activity than was shown by the other subject. Each subject traced 63 stars in all.

The stars in the right hand column of figure 3 are given for comparison. C1 is the first star traced by an average graduate student; C2 is the second star she traced and C3 is her twelfth. It must be remembered, however, in making comparisons with the stars traced by B and E that these girls were using their non-preferred hands while the graduate student used her preferred hand. C4 is a typical first attempt of an adult as given by Starch (3).

Progress both in eliminating error and in lessening time is clearly indicated by the graphs in figure 4. The ordinates represent the average number of errors (the solid line) or the average time in seconds (dotted line). This graphical representation shows nicely, too, the acquirement of superiority of the right hand over the left hand in time taken and in the number of errors made, the 4 arrows on the right representing the level of preferred hand achievement.

PRACTISE EXERCISES

On January 11, the third part of the experiment was introduced. As emphasized in the earlier part of this paper, some scheme must be divised in order to have the children write with their right hands without calling attention to the writing itself. For this purpose a number of brightly colored flash-cards were made. The cards measured 5 by 7 inches and the subjects chosen were of a very diversified nature to eliminate monotony and hold the girls' interest. Some cards contained words printed in various styles of lettering, others depicted common objects while still others represented people performing some actions, such as sneezing, eating, etc. (see figure 5). The cards were shown for such a very brief space of time that the subjects had to focus their attention upon them in order to see what was pictured. Some of the cards showed several objects and the subjects had difficulty in finding just what the experimenter wished them to see, or rather, pretended to wish them to see. This situation added greatly to the interest created, by introducing an element of competition. The experimenter, of course was not interested in what was written down, but in the writing, the subjects were interested not in the writing but in what they wrote.

The subjects were given the following instructions:

> "I am going to show you a card on which something is written or pictured. I shall let you look at it for one second, then I want you to write down as quickly as possible the word or object you saw. If you see the picture of a person doing something, write what the person is doing. Your writing and spelling doesn't matter, but I want you to use your right hand and write quickly so you won't miss the next card. Ready. Write!"

On the first day 18 cards were exhibited and the subjects wrote with their right hands on lined paper with pencils. E-R2 and B-R2 of figure 6 show the result of this exercise.

On January 25 and again on February 1, 21 new cards were used, the sub-

FIG. 5

jects being given the same directions. The cards were held so that they were plainly visible to both subjects. For variation, on February 15 an "opposites" test and a "whole-part" test, each requiring 20 words to be written, were employed. The cue words were dictated by the experimenter. Some of the words written by the girls during these tests are given in figure 6, at E-R3 and B-R3.

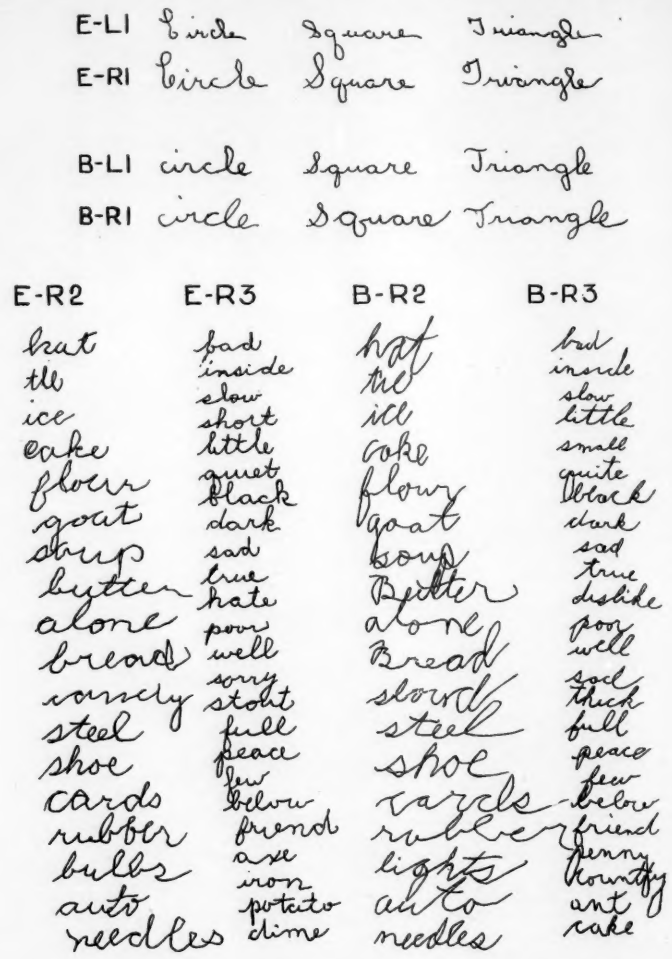

FIG. 6

The remarkable progress in writing

made by the subjects during the experiment is shown in figure 6. E-L1 and B-L1 were written on November 2 when the girls were asked to write as they did in school (with their left hands). On the same date they were asked to write the same words with their right hands, it being stressed that their very best writing with that hand was required. Thus, E-Rl and B-Rl show right hand performance when particular attention was called to the writing. In E-R2, E-R3, B-R2 and B-R3 attention was directed away from the writing. It will be noticed that, at E-R3 and B-R3 the act of writing with the right hand has become practically automatic, the quality of this writing approaching very closely to that done when the whole attention was directed to the writing. The progress in execution from E-R2 to E-R3 and from B-R2 to B-R3 is quite obvious from the figure. All parts of figure 6 were reduced one half.

At this time the teachers who taught the girls in public school were interviewed, and their coöperation sought in giving more frequent practise in writing with the right hand than the experimenter was able to give as he met the subjects only once every two weeks. E's teacher seemed to understand what was required but probably the experimenter's request called undue attention to writing as the teacher noticed for the first time that E frequently made n's like u's though the experimenter had noticed that little idiosyncracy the first time the subject had written her name on the blackboard—to be definite, on November 23. The teacher reprimanded E for her n's. As E had never had any trouble in school previous to this time E's mother was very upset and blamed the experimenter for ruining E's writing with her left hand. She was only pacified when the experimenter showed her some of E's writing that had been done before the experiment commenced in which were found some n's that looked like u's. In a moment of confidence E told the experimenter that her father made that kind of n's, that she liked them, had been making them for a long time. and was going to continue to make them. The experimenter persuaded her to make them the way the teacher wanted them as long as she was in that class.

B's teacher too, was well meaning but her method was confusing and interfered with that of the experiment. She made B write exclusively with her right hand instead of having her write a little each day as the experimenter had suggested. B complained of being tired but the teacher insisted. B complained at home that the teacher was trying to "break" her from writing with her left hand. The parents objected very strenuously to having B "broken" and it required much tact to convince the parents that the experimenter at least was not trying to "break" B of anything. It is to be noted here that even one word such as the word "break" may wreck an experiment that has been going along successfully for months.

The entire procedure outlined in this paper might well be termed an experiment in methodology. The results seem to be on the whole positive

and the method used here gives many indications of solving, partially, at least, the problem of parents and teachers as to what to do with the child who writes with the left hand. If the child is started early enough, if the teacher or parent is tactful and patient, and if the method used is one which minimizes to the lowest degree the importance of the writing done and places sufficient emphasis outside the writing —emphasis which diverts the attention from such things as the awkward "feel" of the pencil in the hand, poor coördination (the hand won't do what you want it to), undeveloped musculature etc.—then, success is assured. The child will probably never forget habits learned with the left hand but he will acquire habits with the right hand, so that performance with that hand will equal or surpass performance of the formerly preferred hand.

Not all of the exercises were continued till the right hand surpassed the performance of the left, but in the star-tracing this was certainly the case, to the surprise of the subjects who could hardly believe that they could trace stars better and faster with their right hands than with their left.

The subjects were observed very closely both by their parents and by the experimenter to note whether there was any interference in their speech. At no time was any stuttering or stammering detected, proving quite conclusively that in some cases manual activities may be learned by the non-preferred hand without causing an emotional upset and consequent speech defects.

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The "Negative Phase" in Relation to the Behavior of Pubescent Girls

E. B. Hurlock and S. Sender[1]

ALTHOUGH a number of books have been written on adolescence and its most outstanding characteristics, little attention has been given to the pre-pubescent and pubescent stages, and even less time has been devoted to a study of them. Recently, however, an increased interest has been shown in this subject, and a few investigations have been made. In Germany and Austria especially, some observational studies have been made of these stages. In the United States, a few studies have been carried out to discover the relationship between physical maturity and certain personality traits of boys and girls.

A summary of these studies will be made under the following headings: (1) meaning of the term Negative Phase; (2) its source of interest; (3) its characteristics; and (4) observations made of the Negative Phase and other studies of physical maturity.

MEANING OF THE TERM, NEGATIVE PHASE

Professor Charlotte Bühler of Vienna has given the name, Negative Phase, to a behavior period of short duration (two to nine months) preceding puberty in boys and girls. This term seemed to her to describe adequately the feelings and behavior of boys and girls during this particular stage of physiological development. The term is justified on the grounds that there appears to be a complete reversal of the usual behavior of the individual, so that conditions which evoked a certain response before this period, now evoke passivity or the opposite of the usual response.

SOURCE OF INTEREST

As has been the case with many psychological investigations of childhood and adolescence, Professor Bühler's attention to the Negative Phase was first attracted by literature. Her source was the diaries written by boys and girls soon after puberty. In the case of the former, the average age was fifteen, and in the case of the latter, fourteen. In these diaries, (4) she was impressed by the constant reference of the writers to their feelings of stress, generally characterized by a desire to withdraw from society, which occurred shortly before puberty, the Negative Phase of development. In the 1929 edition of her book (3) the number of diaries available for her study was 52. From these, she has

[1] The junior author gathered and tabulated the data for this study: the senior assisted in planning the study, in the interpretation of its results, and in writing this report.

generalized concerning the mental and emotional tendencies characteristic of pubescent youth.

CHARACTERISTICS OF THE NEGATIVE PHASE

Because of the large number of characteristics of the Negative Phase, it is desirable to group them in two categories, general and specific.

General characteristics

The following description of the Negative Phase has been translated from Bühler's (4) work based on a study of diaries of boys and girls.

> "An appearance of disinclination; restlessness; a physical and mental uneasiness which finds expression in obstinacy, ferocity, waywardness, and indolence; irritability, melancholia; hatred of self and society as well as hostility toward the latter. During this period their lives are joyless and tiresome; everything is unwelcome and appears evil or bad. Since the process of maturing uses up a good deal of the energy of the person, there results anemia, tiredness, or lassitude. Heightened sensitivity, irritability, restlessness, and the ease with which they can be excited are characteristics of the life of a pubescent."

Hildegard Hetzer, (9) using the results of her observations of a group of girls, states that, "this phase is characterized by passivity and restlessness; loss of interest; desire for isolation, neglect of productive activity; instability; restlessness; loss of skill of performance; withdrawal from friends, parents, and teacher." On the other hand, Lucia Vecerka (17) found that those girls who were orphans, at this time longed for their parents.

Although not referring to this Negative Phase as such, August Kohl (11) describes the feelings, thoughts, and behavior of the pubescent quite similarly to the two preceding accounts. "How many young people groan under the yoke of the new, strange loads which puberty brings them? How much heartache does the attempt cost our half-grownups to compromise, unguided, with the difficult, puzzling facts of a new life-epoch?"

Special characteristics

Some of the special characteristics of the period suggested by different writers are as follows:

Associations. There seems to be a general opinion that the character of associations undergoes a definite change at the time of puberty.

Lucia Vecerka (17) found that prepuberty associations are comradeships which are formed with many and which do not entail purely personal participation. During puberty or soon after, the associations are friendships with one individual only, seeking mutual understanding. There is a return to the comradeship type toward the end of adolescence when the individual joins societies.

Up to thirteen years and five months, there were no general discrimination qualifications for the friendships. After that age, or during puberty, the girls would rather forego friendships than not have the ideal friend. Some of the qualifications for such a friendship are, according to her findings: "the friend must be a lover of truth; must be able to keep still; have strong principles; be intelligent; be understanding and happy; must have no secrets from each other; each must have the courage to tell the other of

her mistakes; must love each other." Hetzer (8) has noted that in her group of girls the tendency was toward a decrease in the number of friends as well as toward a change in the character of the associations.

Oskar Kupky (12) noticed a similar change in the character of the associations of boys before and after puberty.

Paul Hanley Furfey (6) pointed out in his book on the gang life of boys that the ages for joining the gang are from ten to fourteen or puberty. At, and after puberty, there is a sharp falling away from participation in gang activities.

Leadership. Hetzer (8) found that during the Negative Phase, changes occurred both in the character of and desire for leadership. A number of girls relinquished their positions as leaders and would have nothing to do with the group formerly led by them. Some of them regained their positions later; others did not. On the other hand, a few during this period attempted to become leaders. They were the girls who never before had been leaders. The method of attaining this end by these girls was radically different from that of the girls who obtained leadership before puberty. Whereas the latter had reached their position through superiority in some special ability, the former attempted to gain leadership through force, intimidation and coercion.

Influence of depraved elements. The leader at this age is often of "ill-repute" as Hetzer (8) describes her. Although the girls avoided her before and after this phase of development, nevertheless, while they were passing through the Negative Phase, they grouped themselves about her. At the same time, the girls avoided the person supervising their activities, in whom they previously confided and asked for advice. They grouped and banded only for the purpose of discussing sexual explanations and reading disreputable literature.

Hetzer (8) emphasizes the fact that during this period girls are more liable to allow this influence of disreputable and depraved elements to lead them to actual misdemeanor or sexual delinquency. This emphasis is given additional weight by Charlotte Bühler's (3) confirmation through a survey of the statistics for a ten years' period of a Juvenile Court in Berlin. The statistics revealed that there was a preponderance of sexual delinquencies during the thirteenth year, the time of the Negative Phase.

OBSERVATIONS OF THE NEGATIVE PHASE AND STUDIES OF PHYSIOLOGICAL MATURITY

In 1926, Hetzer (8) who was in charge of an "Hort" (an after-school recreational center) in Vienna where boys and girls came very day after school made an observation of the Negative Phase. She noticed during the year that some girls without apparent cause seemed to change. They became negligent in their work, restless, avoiding former friends, and forming friendships with girls of ill-repute who were generally avoided. Upon closer observation she found that this change in behavior occurred a short time before the establishment of menstruation, when the restlessness and tension, during which no work could be accomplished, ceased and a

return to former positive behavior was made.

A great number of the girls began to write stories, diaries, and letters to imaginary persons or to Miss Hetzer, soon after their emergence from the Negative Phase.

"The first productive activity at the termination of the negative phase," according to Hetzer, (8) "is literary. Letters, dramas, plays, diaries, and stories are the vehicles of expression. . . . . The writings of puberty are not the writings of giftedness, but of development. Later, attempts at creative expression may be voluntary, but during puberty, one is driven to expression."

Another Viennese study in regard to the social relations of girls during puberty was made by Lucia Vecerka (17). She had in all 1492 girls ranging in age from eleven to twenty, but used her own classes for intensive study. Specifically, through the means of a questionnaire, she found that preference for being alone is an outstanding characteristic of puberty.

Mary A. Leal (13) carried out an investigation in the schools of New Britain, Connecticut, to find out the relationship between physiological maturity and certain characteristics of boys and girls. She used the questionnaire method. These questionnaires were given to the teachers who listed the pupils manifesting the various characteristics named, among these were: impatience with restrictions; self-assertion; interest in opposite sex; avoidance of opposite sex; cooperation; gregariousness. The physiological development of each pupil had been ascertained through the use of standard criteria for each of the three levels: pre-pubescent or immature, pubescent or maturing, and post-pubescent or matured development.

She found that all the traits she had listed occurred to a lesser or greater extent in all the three stages of development with the exception of gregariousness which occurred in girls only in the matured stage. The occurrence of some traits, however, were influenced by the type of maturity: early, normal or late. The appearance of other traits seemed conditioned by the I.Q., and still other traits were associated with chronological age.

In girls of high I.Q., impatience with restrictions increased with age, while loyalty to a cause decreased with age. In girls of normal I.Q., the avoidance of the opposite sex increases with age, and loyalty to a principle and clique decreases with age. In girls of low I.Q., on the other hand, the avoidance of the opposite sex decreases with age as well as loyalty to a principle.

In regard to the type of maturing, the early and normal types show interest in the opposite sex, whereas the late maturing avoid the opposite sex. The normal and late also show impatience with restrictions.

PURPOSE OF PRESENT STUDY

The purpose of the present study is two-fold: first, to verify the inevitable occurrence of the Negative Phase in pubescent girls which according to Hetzer (9) "is a first step or concomitant of puberty. Omission of this phase is due to precocity or sexual misdemeanor," and, secondly, to ascertain whether sexual delinquencies occur predominantly during the thirteenth year, the time of the Negative

Phase which Charlotte Bühler (3) found to be the case in her study of cases in a Juvenile Court in Berlin.

To our knowledge there has been no study devoted exclusively to the Negative Phase as a whole with the exception of Miss Hetzer's (8) whose investigation has already been described in detail. This study will, therefore, deal in the main with the results of her observation.

METHODS OF PRESENT STUDY

Questionnaires

A study of records of high school girls was attempted, but after visiting a number of institutions and reading numerous cases, it was found that none kept records of systematic observations of the behavior of the girls; nor did many have recorded the dates of the establishment of menstruation. This method of procedure was, therefore, abandoned for that of the questionnaire. Two forms of a questionnaire were prepared: one, to be submitted to girls of the ages between twelve and fourteen; and the other, to be sent to individuals who come in contact with girls of these ages and are in a position to have noticed or to notice the occurrence of the characteristics of the Negative Phase. Unfortunately, the former questionnaire could not be used since no school would permit to be circulated among their girl-pupils a paper containing references to their emotional or mental condition during puberty, lest it cause unnecessary talk among them and direct their attention to an "unhealthy subject."

Five hundred questionnaires of the second form were circulated (1) among Junior High School advisors or principals who took charge of behavior problem girls, and who would, therefore, come in contact with girls under the influence of the Negative Phase; (2) among Junior High School physical training teachers who, through the periodic health examinations, are informed of the physiological development of the girls and at the same time are able to notice the appearance of many of the Negative Phase traits; as: passivity, coöperation, and leadership, etc.; (3) among matrons in charge of homes, settlement houses and institutions; and (4) among school teachers. In order that the reports should not be restricted to any one economic or social class the questionnaries were distributed in different parts of New York City to get samplings from different social and economic groups.

The questionnaires used in this study were constructed from points taken from Miss Hetzer's (8) results of her observations on the Negative Phase. Copies of the questionnaires are given on page 330.

Court cases

In addition to the questionnaire method, court cases were studied in order to see: first, how many of the girls brought to court had recently established their menstruation; and, secondly, to find out whether the largest number of sexual delinquencies occurred during the thirteenth year, time of the Negative Phase as Charlotte Bühler (3) found in her survey. These cases, numbering 142, were read at the Mental Clinic of the Children's Court of the City of New York at 137 East 22d Street, with the permission

QUESTIONNAIRE (For Teachers)

Instructions: Please check the answers.

Have you noticed any of the following changes in behavior of girls about 12–14, a short time before menstruation was established?

In what per cent of girls do you judge these changes to occur?

1. Loss of interest in: school....., work....., play....., home....., friends.....
2. Desire to be alone? Yes..... No.....
3. Neglect of creative activity, such as playing piano, painting, etc. Yes..... No.....
4. Restlessness..... Instability.....
5. Withdrawal from companions? Yes..... No.....
6. Withdrawal from parents? Yes..... No.....
7. Withdrawal from leadership in group? Yes..... No.....
8. Hostility toward society? Yes..... No.....
9. Hostility toward members of family? Mother..... Father..... Sister..... Brother.....
10. Tendency to be destructive? Yes..... No.....
11. Did any of the girls confide in you? Yes..... No.....
12. In what per cent of the cases?.....

Any additional information may be written under "Comments."

COMMENTS

.....

.....

QUESTIONNAIRE (For Girls)

Instructions: Do not sign your name. Please check the answers.

AGE:

AGE OF FIRST MENSTRUATION:

Did you experience any or a number of the following changes in behavior a short time before menstruation was established?

1. Loss of interest in: school....., work....., play....., home....., friends.....
2. Desire to be alone? Yes..... No.....
3. Neglect of creative activity, such as playing piano, painting, etc. Yes..... No.....
4. Restlessness..... Instability.....
5. Withdrawal from companions? Yes..... No.....
6. Withdrawal from parents? Yes..... No.....
7. Withdrawal from leadership in group? Yes..... No.....
8. Hostility toward society? Yes..... No.....
9. Hostility toward members of family? Mother..... Father..... Sister..... Brother.....
10. Tendency to be destructive? Yes..... No.....
11. Did you want any person to confide in? Yes..... No.....
12. Did you confide in anyone? Yes..... No.....
13. In whom did you confide? Mother....., Teacher....., Friend....., Relative.....
14. Duration of period.....

Any additional information may be written under "Comments."

COMMENTS

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of its director, Dr. Helen Montague. They covered the years 1928–1929, and were for girls twelve, thirteen, and fifteen years of age. Girls in the last year group were used as controls for the first two groups. Each of these cases had complete family developmental and social histories as well as physical and psychological examinations.

TABLE 1

Questionnaires. Percentage of girls in each group showing "negative phase" traits

TRAIT	TRAIT OCCURRENCE FOR TOTAL RETURNS OF QUESTIONNAIRES	GROUP FROM POOR HOMES IN RELATION TO TOTAL RETURNS	GROUP FROM POOR HOMES	GROUP FROM BETTER HOMES
	per cent	*per cent*	*per cent*	*per cent*
Loss of interest in school	35	25	62.5	17
Loss of interest in work	25	15	37.5	17
Loss of interest in play	20	15	37.5	8
Loss of interest in friends	35	25	62.5	17
Desire to be alone	35	25	62.5	17
Neglect of creative activity	35	10	25	42
Restlessness	65	35	88	50
Instability	45	30	75	26
Withdrawal from companions	35	25	62.5	17
Withdrawal from parents	15	5	12.5	17
Withdrawal from leadership	25	15	37.5	17
Hostility toward society	25	20	50	8
Hostility toward members of family	6.25			10
Mother	5			8
Father	5			8
Sister	5			8
Brother	10			17
Tendency to be destructive	30	25	62.5	8
Did any confide in you	40	30	75	17
Percentage confiding	40	30	75	17

RESULTS OF PRESENT STUDY

Questionnaires

One hundred and sixty questionnaires were answered and returned. The results have been assembled in table 1. It was found expedient to distribute the results of the returned questionnaires into the four columns of table 1 in order that the significance of the results may be more adequately revealed and more easily comprehended. The first column contains the percentages of occurrence of the Negative Phase characteristics in relation to the total returns; the second column contains the percentages of the occurrence of these characteristics in the girls from poor neighborhoods in relation to the total returns; the third column contains the percentages of the occurrence of the characteristics in the girls from poor neighborhoods in relation to the total questionnaires returned from schools situated in those neighborhoods; the fourth column con-

tains the percentages of the occurrence of the characteristics in girls from better neighborhoods in relation to the total questionnaires returned from schools situated in those neighborhoods.

Considering the columns one by one, we notice that the largest percentage (65) for the occurrence of restlessness, and the next largest (45) for the occurrence of instability. Loss of interest in school and friends, desire to be alone, neglect of creative activity, and withdrawal from companions, each have the same percentage of 35, while the tendency to be destructive occurs in 30 per cent of the reports. Loss of interest in work, withdrawal from leadership, and hostility toward society, each has a somewhat reduced figure of 25 per cent. Except for restlessness, then, the percentages of occurrence of the characteristics descriptive of the Negative Phase are all below fifty. One would conclude, therefore, that generally the behavior of the Negative Phase is not concomitant with puberty. However, let us consider the data contained in the other columns which contribute toward the make-up of the first column.

In comparison with the first column the second column contains relatively large percentages of occurrence of the traits. This fact is more clearly evident in the figures of the third column which indicates the percentages of occurrence of the Negative Phase behavior in girls from poor neighborhoods in relation to the total number of questionnaires returned from such sections. The majority of figures exceed the fifty per cent mark; restlessness 88 per cent; instability 75 per cent; loss of interest in school and friends, desire to be alone, withdrawal from companions, and the tendency to be destructive each reach the relatively high figure of 62.5 per cent; while hostility toward society receives exactly 50 per cent.

The fourth column shows relatively the smallest percentages of occurrence of these traits, only restlessness receives 50 per cent and neglect of creative activity, 42 per cent. With the exception of instability the remaining characteristics do not receive percentages higher than 17. The higher percentages for neglect of creative activity here than in the other columns may be explained by the fact that in the well-to-do homes the girls are given the opportunity to take lessons in some creative expression, as piano-playing, dancing, painting, drawing, etc. Neglect of these activities, therefore, would be noticed more amongst this group than in that of a poorer group who had no opportunities to develop or train along these lines.

It is also interesting to note that hostility toward parents occurs among the better class girls rather than the poorer class. However, this fact is not so surprising after analysis. It is well known to people in contact with foreign families that the parents have little control over their American born children and the latter have little respect for the parents. Even in the cases where there are strict fathers, the children have their way because the mothers are usually weak disciplinarians, relying on the threat to tell the father. When the father comes home at night, the complaint is forgotten and the child goes scot free.

However, for the closer supervised girl of the better class, the chances for friction during this period of development manifested generally by restlessness are greater and hostility toward the parents is the result.

The increased hostility toward the brothers of the family would agree with Leal's (3) findings that at puberty girls show increased avoidance of the opposite sex. However, it would be worthwhile to know the ages of the brothers, since many writers have noticed that girls during this period of development prefer older men, because maturing earlier they resent the un-

TABLE 2

M.A., I.Q., and grade status of delinquents studied

	RANGE	AVERAGE	MEDIAN	σ	$P.E._{av.}$
12 year old group. 39 cases (1928–1929 records)					
M.A.	6–11	9.07	9.08	1.29	0.95
I.Q.	50–90	73.98	70.32	10.81	7.72
Grade status	3A–8A	4B–5A	4B–5A	2.4	1.3
13 year old group. 59 cases (1928–1929 records)					
M.A.	7–16	10.72	10.50	1.69	1.19
I.Q.	52–124	78.79	77.37	14.23	8.80
Grade status	4A–9B	6A	5B–6A	2.48	1.46
15 year old group. 44 cases (1929 records)					
M.A.	7–17	11.08	10.72	2.29	1.54
I.Q.	48–120	73.45	71.36	16.71	10.24
Grade status	4B–High School	7A	7A–7B	3.06	2.34

TABLE 3

I.Q. scores for types of delinquency

12, 13, and 15 year old groups combined. 142 cases (1928–1929 records)

CHARGE	NUMBER OF CASES	PER CENT OF DELINQUENCY IN RELATION TO TOTAL DELINQUENCIES FOR GROUPS COMBINED	RANGE	AVERAGE	MEDIAN	σ	$P.E._{av.}$
Sexual delinquency	60	42	48–116	71	71.53	12.14	7.37
Incorrigibility	17	12	53–95	77.35	77.5	10.58	5.07
Truancy	5	3	65–85	77	77.5	7.48	6.25
Desertion	35	24	55–120	83.57	84.50	16.72	12.38
Neglect	16	11	52–124	76.87	76.66	15.09	7.5
Stealing	6	4	60–80	71.67	70	7.45	6.25
Sundry	3	2	68–86	78	82.5	16.27	9.37

sympathetic behavior of the immature boy of the same chronological age. Except for restlessness then, Negative Phase behavior is not manifested by this group of girls.

Inasmuch as the majority of the reports contained in column 3 came from the same congested East side neighborhoods as the delinquents studied at the Mental Clinic, it may be assumed that the similar social, economic, and mental conditions obtain for both groups. With this assumption, as we can draw upon the tables describing these conditions of the delinquents.

TABLE 4

Home conditions of delinquent group

CONDITIONS	PER CENT OF CASES
Parents living together	42
Homes without fathers	16
Homes without mothers	15
Both parents absent (living with relatives)	22
Parents not married	5

TABLE 5

Percentage of native and foreign-born delinquents

	PER CENT OF CASES
Native-born children—native-born parents	34.51
Native-born children—foreign-born parents	53.73
Foreign-born children—foreign-born parents	11.76

Table 2 gives a mental picture of these girls brought to court: they are all in the borderline class on the average, three to four years retarded mentally and one to two years backward in school. This general description of their mental development agrees entirely with that of the group observed by Hetzer (8).

TABLE 6

Family income in relation to number of children

FAMILY INCOME PER WEEK	PERCENTAGE OF FAMILIES
Two children per family	
dollars	*per cent*
25	31
26–32	14
33–40	20
41–49	11
50 and above	24
Three children per family	
25	20
26–32	17
33–40	21
41–49	15
50 and above	27
Four children per family	
25	19
26–32	15
33–40	20
41–49	14
50 and above	32
Five children per family	
25	13
26–32	14
33–40	21
41–49	15
50 and above	37

The parental conditions indicated in table 4 show that more than 58 per cent of the children have either no fathers, no mothers, no parents, or the parents are not married. These home conditions are conducive to lack of

supervision. In the 31 per cent of the cases where there is either no father or mother, it means that either the oldest girl, who may be younger than a number of her brothers, supervises the home, or the children are left alone, because the father or the mother must work. No doubt, as a result, the street is the children's playground. Hetzer's (8) group was equally unsupervised.

Table 5 shows that 65.49 per cent of the delinquents are native or foreign born children of foreign born parents, the majority (54 per cent) comprising

TABLE 7

Number and percentage of sexual delinquencies in each year group (1929 records) in relation to the total delinquencies for the three year groups (12, 13 and 15 year old girls)

YEAR GROUP	NUMBER OF SEXUAL DELINQUENCIES	PER CENT OF SEXUAL DELINQUENCIES
12	11	31
13	12	33
15	13	36

the group of native born children of foreign born parents. The behavior of these children toward their parents has already been discussed.

In table 6 are given the economic conditions of the families from which the delinquents came. Thirty-one per cent of these families consisting of husband, wife, and two children, live on twenty-five dollars a week; twenty per cent of them consisting of husband, wife and three children subsist on twenty-five dollars a week. And, unbelievable as it may seem, nineteen per cent of the families, father, mother and four children, exist on twenty-five dollars a week. Forty-two per cent of the families are comprised of six children, father and mother, and have an income of fifty dollars a week.

To sum up, the home conditions of these girls are deplorable, the economic status inferior, and their mental development retarded. No doubt, under these conditions, they would also be undernourished. Although in a few cases the physical conditions of the girls were mentioned, it was not done consistently enough to obtain figures on it.

It would seem then that restlessness and instability generally are concomitants of puberty. The other characteristics of the Negative Phase are manifested by girls who lack self control and good training. As Hetzer (8) observed, the girls in her group also gave vent to their feelings and emotions easily and unrestrainedly. Her conclusions in regard to the occurrence of the Negative Phase characterized by the traits listed in table 1 have been substantiated by the group from the poor neighborhood but not by the group from the better sections of the city. In her conclusion that these characteristics are concomitant with puberty, she failed to specify that these might be applicable only to the group she observed. She generalized the behavior of the observed girls and supposed that the Negative Phase is a stage through which all girls pass.

It may be illuminating to cite the contents of some of the questionnaires characteristic of the two groups. The following quotations are from schools in the better neighborhoods, "I have never experienced any very unusual

cases in my teaching here," and "we notice that girls are irritable at this time, and unusually nervous, but not behavior problems; this irritability ceases when menstruation is established." However, a questionnaire returned from a girls' home states that 50 per cent of the girls lose interest in school, work and play; desire to be alone; neglect creative activity; show restlessness; withdraw from their companions; and become hostile toward society. This hostility toward society on the part of the girls in homes is explained by the matrons by the fact that girls at this period of development become sensitive to living in a home; become resentful and blame society at large for their plight. Girls at this time will also rebel at very strict and what they consider unsympathetic supervision.

This lack of restraint in expression of feelings and emotions at the time of puberty, therefore, may be due to lack of training in self-control, lack of supervision and direction in the child's activities, or lack of mental and social development to realize the offensiveness of his behavior, rather than to the physiological condition which is characteristic of this period of the individual's life.

Court cases

An examination of the court records showed that a majority of the girls were of foreign parentage; i.e., they are the first American born generation of parents born abroad. Table 5 reveals that 54 per cent of the delinquents belong to this group. A great number of the parents are illiterates, both in their own and in the English language. Some are not even able to speak English, although they have been in the United States more than fifteen years. This illiteracy may be the result of lack of opportunity to learn, but after reading the case histories the impression is given that it is due rather to their dullness or inability to learn. In the main, the fathers are unskilled manual laborers of an inferior social status.

The home conditions of these girls are far from favorable as has been mentioned previously. Table 4 makes this fact clear. Thirty-one per cent of the families lack either a father or mother. In either case, the parent is absent all day at work and the children are left to their own devices or to the supervision of the oldest sister. There is, therefore, little supervision of their behavior, direction of their play which takes place on the streets, or knowledge about their associates. In 32 per cent of the 142 cases studied, the mother is working either because the husband is dead, has deserted, does not earn enough to support the family, or is not employed steadily.

Nor are the neighborhoods from which these girls come any better, since their locations are on the lower East side of New York or in other congested areas of the city. Inasmuch as the parents are foreigners who speak little English, they tend to settle in their respective congested national districts, where any attempt at Americanization is unnecessary for them to get along in business or social life.

The pitiably small incomes of the families of these girls is shown in table 6. Thirty-one per cent of these families consisting of the parents and

two children live on twenty-five dollars a week. Forty-two per cent of the families including father, mother and six children subsist on fifty dollars a week. Twenty per cent of the families comprised of father, mother, and five children exist on thirty-three to forty dollars a week. These are some of the deplorable environmental conditions.

An inclusive description of the mental development of these girls can be obtained from table 2. The twelve year olds are in the borderline class, retarded three years mentally and two years scholastically; the thirteen year olds are also in the borderline class, retarded three years mentally and one year scholastically; and the fifteen year olds are in the borderline classification too, retarded four years mentally and two years backward in school. Although the I.Q. scores and Mental Ages of the other two groups are not much higher than those for the twelve year olds, yet their scholastic attainments are greater. This is perhaps due to the practice of promoting boys and girls on the basis of their chronological age rather than on the basis of their mental ability.

Table 3 shows the percentages and I.Q. scores for the same kind of delinquencies for all the three year groups. The sexual delinquencies have the highest percentage of occurrence and their average I.Q. score is the lowest for all the delinquencies. This fact agrees with the findings of Leal (13) that in girls of low I.Q. scores the avoidance of the opposite sex decreases with increasing age.

In reading the cases, the writer came across the expression occasionally that the misbehavior had recently started. It was also found that the girl had but recently established her menstruation. These occurrences were very few, only five or six in the entire group.

From the foregoing consideration of the sexual delinquents, it would seem that the girls of this group are more suggestible for reasons other than merely the physiological. A large number of these sexual delinquents had been raped, but the impressive feature was that they failed to resent these forced relations. Perhaps the charge of rape was an alibi for the judge. Others asked men in the streets for money to buy candy or go to the movies and submitted to the men's advances. Some were initiated into the sexual delinquencies by bad companions. The single characteristic feature of all these girls seems to be lack of social judgment or sensitiveness to social approval or disapproval. This lack of regard for the opinion of others may be the result of a number of factors: insufficient supervision by parents, subnormal intelligence, bad companions, physical inferiority, or debasing surroundings in the home and neighborhood. As so many of these girls were exposed to a number of the above mentioned undesirable factors, one cannot attribute the delinquency to any one of them. Furthermore, many of the family histories mentioned sisters, both younger and older, living in the same environment, and of practically similar caliber, as determined by their school grade attainments, who were sexual delinquents. It seems, therefore, that the cause for the delinquency is to be found in the girl's own individual makeup, which is influenced by conditions and circum-

stances which might not affect others of different makeup.

Because of their intellectual retardation, these girls probably cannot sublimate their sexual desires in intellectual and esthetic appreciations which appear generally as new capacities in the intelligent adolescent. Many of this group had just come out of homes where they had been emotionally suppressed and isolated from normal social contacts. As a result of this environment they are apt to become delinquents when released at the critical time of puberty.

SUMMARY

1. The questionnaire study of occurrence of the Negative Phase traits in pubescent girls showed the highest percentage (65 per cent) for restlessness and the next highest (45 per cent) for instability.

2. Loss of interest in school and friends, desire to be alone, neglect of creative acivitity, and withdrawal from companions, each had the same percentage (35 per cent) of occurrence.

3. The tendency to be destructive occurred in 30 per cent of the reports, while loss of interest in work, withdrawal from leadership, and hostility toward society, each had a somewhat reduced figure of 25 per cent.

4. There was a wide disparity between percentage of occurrence of the Negative Phase traits in girls from poor homes and those from better homes.

5. The occurrence of these traits in girls from poor homes constituted 80 per cent of the total occurrence of hostility toward society; 71 per cent of loss of interest in school and friends, desire to be alone, and withdrawal from companions; 60 per cent of loss of interest in work, withdrawal from leadership, and instability; and 54 per cent of restlessness. Restlessness is about evenly distributed between the two groups.

6. The girls reported showing behavior characteristic of the Negative Phase belong to an inferior social and economic level, have deplorable home conditions, and are of retarded mental development.

7. These girls live in the foreign settlements and other congested areas of New York City.

8. The results of the study of court cases did not show a preponderance of sexual delinquencies during the thirteenth year, although the percentage of sexual delinquencies in relation to the total delinquencies of the twelfth and thirteenth year groups respectively were larger than that for the fifteenth year group.

9. Sixty-five per cent of the delinquents are native-born of foreign-born parents; 58 per cent of them had either no father, mother, parents, or the parents were living together unmarried. Thirty-five per cent of the families consisting of father, mother, and two children, had an income of twenty-five dollars per week; while 20 per cent of the families consisting of parents and three children also lived on an income of twenty-five dollars per week.

10. The majority of delinquents came from the poor, congested areas and East Side of New York City.

11. On the average, the delinquents of all groups were of borderline intelligence. They were retarded two

to four years scholastically, and three to four years mentally.

12. The average I.Q. scores for sexual delinquencies is the lowest of that for all delinquencies and decreases with increased age.

It would seem, therefore, that bad environment, undisciplined up-bringing, lack of self-control, and mental retardation, which are a few of the descriptive conditions of the girls from poor homes, have something to do with the occurrence of Negative Phase behavior, since this group showed high percentages for occurrence of the traits characteristic of the Negative Phase. The group observed by Miss Hetzer (8) were of similar social, economic, and mental status. The fact that the Negative Phase behavior was prevalent among them did not warrant the conclusion that the Negative Phase is a "necessary concomitant with puberty." The mental retardation of these girls may be a cause contributing to their misbehavior. No doubt girls of better homes but who have often been pampered would also show Negative Phase behavior. Since their behavior, generally, is wilful and egotistical, the restlessness during puberty would tend to manifest itself in hostility and other traits of the Negative Phase, a mere exaggeration of the normal behavior.

CONCLUSIONS

1. The above data seems to justify the following conclusion: that generally restlessness and instability are concomitants of puberty in girls, but whether this disquietude becomes marked enough to be outstanding depends upon a number of factors, the most important of which are environment and home training. The girls reported showing the behavior characteristic of this phase were from inferior social and economic levels; they lived in poor, congested neighborhoods; were unsupervised in their play and conduct; and suffered from deplorable and undesirable home conditions. Inasmuch as the group Hetzer (8) observed was of similar description, it would seem that the appearance of the Negative Phase in girls shortly before or during puberty depends upon environmental factors, and fits in with the suggestion that developmental maturities can be modified by influences from without. Like the child who has not been trained in the proper manipulation of toys will make random movements with them, so the unsupervised, socially untrained physiological maturing individual will express her restlessness in an uncontrolled manner.

2. The occurrence of sexual delinquency, it would seem, may be conditioned by a great many factors: insufficient supervision by parents, subnormal intelligence, bad companions, physical inferiority, debasing surroundings in the home and neighborhood rather than physiological development. Many of the sexual delinquents in the twelfth and thirteenth year groups had had sexual relations with men from six months to two years previous to arrest. Therefore the sexual drive is only reinforced during puberty and not introduced for the first time, since the delinquencies had already occurred before that physiological period of development was reached. Their mental retardation

probably prevents them from sublimating their sexual desires in intellectual and esthetic appreciation which generally appear as new capacities in the intelligent adolescent. But one must not put too much emphasis upon either the immediate environmental factors nor mental caliber as the fundamental factors in behavior. Rather one must look to the peculiar personality of the individual which is played upon by emotional appeal plus concomitant circumstances.

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Brief Reports

The Kohs Block Design Test

THE Kohs block design test was given to 29 children in the Child Institute of the Johns Hopkins University. The subjects ranged in age from two years four months to five years three months.

PROCEDURE

Sixteen colored cubes were placed on a table before the child so that the single-colored faces were on the top-side of the cubes; there were an equal number of reds, yellows, blues, and whites. The experimenter pointed to a red-topped block, and asked the child to point to all blocks that had the same color on top. The same procedure was used for the other three colors.

After the child showed sufficient color discrimination, a trial design was formed. Pantomime was used freely, with the subject watching closely. The child was then requested to repeat the operation. This procedure was repeated until the child understood. The blocks were then shuffled so that, when placed before the child, no more than one quarter of the blocks had

TABLE 1

Time in seconds

	CHRONOLOGICAL AGE		DESIGN								
	Years	Months	I	II	III	IV	V	VI	VII	VIII	IX
1	3	8	20	35	30.4	46	51	39.4	90	Inc.	18
2	3	10	19	37	21.4	Inc.	66				
3	4	0	73								
4	4	4	25								
5	4	4	26.6	Inc.	31						
6	4	4	25	Inc.	31						
7	4	6	30								
8	4	6	21.4	51	36.6						
9	4	7	37	12.2	19	24	40	16	41	57	36.4
10	4	8	55	36	32	Inc.	41	55	245	40	Inc.
11	4	9	13								
12	4	11	10	Inc.	44	Inc.	25	Inc.	15	24	Inc.
Kohs'	6		72	73	59						
Norm	7		34	72	70	79	92	122	108	76	77

top-side colors which were present in the design, the separate blocks being placed apart, flat on the table, and not piled one on top of another.

The child was told: "What you are to do is this: Take these blocks, pick out the right colors; put them together; and make them look, on top, just like this," (pointing to design which was exposed as model). The time and number of moves were recorded.

Designs 1 to 9 were given except in cases of failure on three successive designs, when the test was stopped.

The time scores for the different designs are given in table 1. These scores for individual designs show the ability of some children at an early age to accomplish this performance for which age norms are not given. The test was scored according to Kohs' score chart, using correctness of design, time, and moves as factors. These scores are given in table 2.

No child in the two year group carried out the instructions. The only response elicited was that of piling the blocks.

TABLE 2

Combined scores and age norms

	C.A.		I.Q.	KOHS' SCORE		C.A. NORMS		M.A.	
	Years	Months		Weighted	Unweighted	50 per cent	75 per cent	Years	Months
1	3	8	127	49	8	10	14+	12	1
2	3	10	158	17	4	8+	9+	8	10
3	4	0		3	1	6	6+	6	3
4	4	4	121	2	1	6	6+	6	0
5	4	4		5	2	6+	7+	6	9
6	4	4	113	7	2	6+	7+	7	3
7	4	6	117	2	1	6	6+	6	0
8	4	6	116	10	3	7+	8+	7	10
9	4	7	100	55	9	11+	16+	12	7
10	4	8	105	36	7	10	12	11	0
11	4	9	87	3	1	6	6+	6	3
12	4	11	121	27	5	9	11	10	2

Two children in the third year group obtained scores of 17 and 49 respectively. Each had had access to colored blocks in the home.

Ten out of seventeen in the four year group made scores ranging from 2 (first design only) to 55 (all nine designs). Some had had access to blocks, others had not.

Neither of the two five year subjects was able to succeed in any design.

PAULINE EIGLER.

Differences in Measurements Made in the Nude and Clothed For Children between Seven and Nine Years of Age[1]

IT IS often necessary to measure children clothed, especially if a large group is being examined in a few hours' time. The value of such measurements as compared with those made with all clothing removed can well be questioned, but judging from the repeated requests for information about differences found between clothed and nude measurements, their relative worth has been clearly recognized by investigators.

Ninety-seven boys and 67 girls between the ages of seven and nine years were measured during the month of January, 1929 according to the technique described by Baldwin (1). They were boys and girls from homes where all the necessary comforts of living were available, so that the amount of clothing which they were wearing could be considered adequate. The study was conducted throughout the month, during a period when the temperature averaged twelve degrees above zero. By accident rather than design the greater part of the work was done when the mean temperature centered near zero. The clothed measurements were made over such clothing as the children wore in a well heated study hall, with shoes and top coats or sweaters removed. Immediately following the clothed measurement, each child was measured in the nude.

The children ranged in age from six years and six months to nine years and five months. They were separated into year age groups in order to find the average differences between measurements clothed and nude at each age, since the relative amount of clothing worn might be different for the younger and older children. The nude values were then subtracted from the clothed and averaged for each sex. The results are shown in table 1. Height is not included because it was only measured in the nude. They tended toward the upper limits of medium build according to the Baldwin-Wood standards. The difference in weight is expressed in pounds, the difference in other dimensions in centimeters.

A ratio was computed by dividing the difference between the means clothed and in the nude by the probable error of the difference to see whether clothing has a marked effect on measurements. A ratio of 3.0 was considered significant. The findings showed that chest circumference and the antero-posterior diameter were increased significantly by the thickness of clothing in the seven and eight-year-old groups of girls. Width of hips at seven and eight and depth of chest at eight were also increased significantly

[1] This study was directed at the Iowa Child Welfare Research Station by Sarah Idell Pyle and Helen Garside Kelly. See Clark, Grace: The relation of the growth of a segment of the chest to general body growth. Iowa Child Welfare Research Station. Unpublished Master's Thesis, 1929, pp. 87.

TABLE 1

Mean differences between measurements for boys and girls clothed and in the nude

AGE, YEARS	NUMBER OF CHILDREN	WEIGHT	SITTING HEIGHT	WIDTH OF SHOULDERS	WIDTH OF HIPS	WIDTH OF CHEST	DEPTH OF CHEST	CIRCUMFERENCE OF CHEST
Boys								
7	37	1.69	0.29	0.34	0.61	0.37	0.37	2.04
8	35	1.86	0.29	0.35	0.71	0.34	0.43	1.82
9	25	2.25	0.22	0.22	0.57	0.39	0.46	1.99
Girls								
7	22	1.39	0.48	0.32	0.48	0.30	0.43	2.05
8	23	1.68	0.40	0.27	0.64	0.32	0.45	2.01
9	22	1.62	0.27	0.28	0.35	0.30	0.43	1.28

TABLE 2

Mean, probable error of mean, standard deviation, and coefficient of variability in nude and clothed measurements

MEASUREMENT	NUDE				CLOTHED			
	Mean	$P.E._M$	S.D.	V	Mean	$P.E._M$	S.D.	V
Girls								
Weight	54.56	0.88	10.8	19.8	56.13	0.90	10.98	19.56
Sitting height	67.89	0.25	3.06	4.51	68.27	0.25	3.04	4.45
Width of shoulders	28.30	0.17	2.06	7.28	28.59	0.17	2.07	7.24
Width of hips	22.35	0.14	1.68	7.52	22.85	0.13	1.62	7.09
Chest circumference	57.92	0.12	4.90	8.46	59.70	0.37	4.54	7.60
Chest width	19.21	0.12	1.50	7.81	19.52	0.12	1.51	7.74
Chest depth	14.77	0.11	1.39	9.41	15.22	0.11	1.34	8.80
Boys								
Weight	54.51	0.59	8.61	15.79	56.40	0.62	9.10	16.13
Sitting height	68.50	0.21	3.05	4.45	68.77	0.18	2.70	3.92
Width of shoulders	28.60	0.11	1.65	5.77	28.92	0.11	1.60	5.53
Width of hips	21.94	0.10	1.47	6.70	22.59	0.10	1.51	6.68
Chest circumference	59.14	0.23	3.33	5.63	61.09	0.24	3.50	5.73
Chest width	19.76	0.09	1.26	6.38	20.13	0.09	1.30	6.46
Chest depth	15.02	0.06	0.89	5.93	15.44	0.06	0.93	6.02

for boys. The other measurements were not greatly affected by the amount of clothing.

Two additional ratios were calculated to test the relation of clothing to size. The first was made between the nude measurements of the children at seven and eight, eight and nine, and seven and nine years. The second ratio was made between the clothed

measurements at the same age intervals. The first showed that these boys were significantly larger at each succeeding year except in antero-posterior diameter of the chest when the ratio was 2.6. There was not a similar outstanding difference in the girls from seven to eight years in any of the dimensions studied, but in each dimension the nine-year-old girls were decidedly larger than the eight-year-old girls.

The second ratio was calculated to bring out the differences introduced by clothing. This ratio ran consistently parallel to the first, and one can infer that in this group the clothing probably did not vary much in type from year to year, but varied as the size of the children varied.

Finally the three age groups were thrown together and the variability of the entire group was computed. The results as shown in table 2 were interesting in that the nude and clothed values proved to be so similar in variability. The measurements for girls clothed were even slightly less variable than those made in the nude. The value of these findings would be clarified by a test of the examiner's precision in locating the proper landmarks when the subject is clothed.

SUMMARY

Measurements clothed and in the nude were made for a group of 97 boys and 67 girls from seven to nine years of age, and mean differences in measurements made by the two methods were calculated. The results showed that circumference of chest, width of hips, depth of chest, and weight were affected significantly by clothing.

There was a significant difference in the various dimensions of the boys in the different age groups at this period of growth. The eight- to nine-year-old groups of girls were relatively larger than the seven- to eight-year-old group. Clothing seemed to vary in amount consistently with size.

When each sex group was considered as a whole regardless of age, measurements clothed tended to be no more variable than measurements made in the nude.

GRACE CLARK.

REFERENCE

(1) BALDWIN, BIRD T.: The physical growth of children from birth to maturity. Univ. Iowa Stud., Stud. in Child Welfare, 1921, 1, No. 1, Pp. 411.

Skill in Progressive Movements of Children

IN A study of the development of motor control in children an attempt was made to get measures of the ability of the child to maintain body balance while walking on a raised pathway. Previous observations had shown lack of control in some children who manifested little behavior such as is usually called fear; in some cases fear was apparent at the beginning of the performance which affected the ability in control and sometimes caused a refusal to undertake the task.

The apparatus used was a walking board which has been distinctly modified from the form originally used by Johnson and described in Mental Growth of Children.

TABLE 1

Walking board

NUMBER OF CHILD	CHRONOLOGICAL AGE		LONGEST DISTANCE								TIME							
	Years	Months	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
			inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*
1	4	8	30	55	35	35	25	40	115	60	27	20	21	16	15	16	14	11
2	4		90	135	60	85					16	8	15	24				
3	4	5	105	55	65						14	20	24					
4	4	4	75	325	135	135					29	34	27	19	18			
5	4	5	95	135	90						23	20	24					
6	4	10	1175	80	675	575					33	30	19	34				
7	4	5	135	50	95	120					11	13	11	10				
8	4	8	135	675	275	50					23	24	22	22				
9	3	7	45	20	35	25	25				74	22	30	24	22			
10	4	4	225	275	35						42	62	62					
11	4	9	135	90	135	135	110				17	13	11	10	15			
12	3	9	475	70	40						38	22	32					
13	4	10	70	65	75	70					13	15	15	13				
14	4		40	25	55						25	42	35					
15	3	11	20	30	40						42	40	31					
16	4	1	35	25	55						64	48	46					
17	5	1	85	135	80						6	12	9					
18	4	3	60	85	75						14	13	10					
19	3	2	15	80	20	50	40				26			17	18			
20	2	8									15							
21	3		5															
22	2	7																
23	4	3									27	36						
24	3	4	50	40							46							
25	3	7	40															
Total			1,356	1,261	1,219	1,280	200				537	475	462	189	88			
Average			71.3	66.3	64.1	12.8	50.0				28.2	25.0	24.3	18.9	17.6			

Not included in averages

To construct the walking board a pine plank 135 inches long, $1\frac{13}{16}$ inches high, and $1\frac{11}{16}$ inches wide was clamped by angle irons on to a redwood piece 135 inches long, 1 inch high, and $8\frac{11}{16}$ inches wide. At each end were screwed platforms 12 inches long, $2\frac{10}{16}$ inches high, and $9\frac{3}{4}$ inches wide. The redwood board was marked off into three sections to facilitate scoring the child's steps off the pine board. We placed yellow numbers 0 to 9 five inches apart, blue from 0 to 9 five inches apart, and white numbers from 0 to 6 five inches apart.

We instructed the child to stand firmly (with both feet) on the platform. The time was taken from his first step on the entrance platform until he reached the platform at the other end. The tendency of the children was to walk straight (placing one foot ahead of the other). One child, however, walked sidewise after failing the other way.

The plan was to count the distance where the child first stepped off and then get him to start over. It was found that the children wanted to walk to the end so the score was taken of points stepped off, total distance (usually 135 inches) walked, and longest distance walked before stepping off. The time required for the performance was kept with a stop watch. The results for individual children are given in table 1.

Six children increased the total distance walked with second and third trials. Others became excited or nervous after first trial and did not walk so far without stepping off. There were five in this group. Three children showed a good performance in all trials. Seven children showed variability in performance from trial to trial. One child, a boy of four years three months, refused to walk; another attempted to walk but after stepping off refused to continue first trial; one other refused to do more than one trial. There was one case of a boy's refusing to do more than two trials. Two of the children in the youngest group appeared unable to accomplish this performance.

The board appears to be promising as a measure of individual differences in body movements within a given age group and in comparison of development from year to year. The emotional elements of behavior play a large part in the variability of performance. This requires more difficult technique for obtaining measurements of motor skill but also offers an opportunity for study of emotional responses.

Dorothy Moore Courtney,
Buford Johnson.

Children's Choices in Modern Art

ELEVEN reproductions of modern paintings were hung on a wall on a level with a child's eyes. The pictures were arranged in order from the most impressionistic to the most realistic and numbered from one to eleven as given below. Each child was placed in front of the pictures and told, "Here are a lot of pictures. Look at them all and show me which one you like best." When one had been pointed out he was prompted to choose

others by being asked, "What other ones do you like?"

RESULTS

Fifteen children were tested, 4 girls and 11 boys, ages three years five months to five years five months. The following is a list of the pictures, giving their titles or subject matter and the number of children who chose each. First to fifth choices were counted when the pictures were really picked out from the rest, but only the first and second choice was used when the child merely pointed to the pictures in order.

1. The Procession (Cubist)	2
2. Improvisation	3
3. Figures on horseback	2
4. Women	0
5. Man on Balcony	2
6. The Goldfish	3
7. Women in garden	0
8. Ball at Arles	2
9. Horse Attacked by Jaguar	6
10. Ship at dock	11
11. Group of women	9

After picking out their first choice 5 children said that they liked all the rest and 7 children pointed to practically all of the pictures in order. Only 3 chose less than ten pictures. Picture number 10 was chosen first by 9 children. No other picture was given first choice by more than one child. Number 10 is a boat picture, numbers 9 and 11 were next in popularity. All three of these were the most realistic of the group. But the choice of 9 and 11 may be due in several cases to their proximity to 10.

CHOICES IN CHILDREN'S DRAWINGS

Twenty-eight children 14 boys and 14 girls, from the Institute of Child Welfare, University of Minnesota, served as subjects. Their age ranged from two years four months to four years eleven months. I.Q.'s from the Kuhlman-Binet and Minnesota Tests were from 85 to 162; M.A. from two years four months to seven years five months.

Ten spontaneous crayon drawings of 5 four-year-old children of the Child Institute of the John Hopkins University were used for presentation. A record had been kept of what the picture was supposed to represent according to the child who drew it. The child was seated in a small chair at a low table with the light from above. The pictures were placed before him on the table one at a time with the instructions, "Tell me what is in this picture," and the added question, "What else?" when the child hesitated. If he pointed at a part of the drawing without naming it, he was asked, "What's that?" When urging was needed to make the child speak, the experimenter repeated the above phrases modifying them as, "Tell me what that is," and "What else is in the picture?"

A record was kept of everything the child named in the picture. From this 3 scores were compiled: (a) the number of pictures correctly named, that is, the number of the times the child named a picture in accordance with the description of it given by the child who had drawn it; (b) the number of objects or parts of pictures correctly named; and (c) the total number of objects named. Details named were counted as separate objects. But calling a picture merely "picture" or "crayons," or naming the colors was

not counted in the score. Nor were repetitions of the same name for the same object in a picture counted. Any name which approximated the correct one was accepted as correct. Thus "girl," "boy," "dolly," and "clown," were counted correct names for the drawing of a human being.

In two of the pictures none of the children was able to recognize an object. The two pictures which were the easiest to name had drawings of people in them. The three which ranked next easiest were of houses.

Two children were unable to name any picture correctly. One child, the youngest, named no objects at all but merely said colors. There was a larger tendency to name colors among the younger children, centering around the age of three years four months.

The largest number of objects correctly named by one child in all ten pictures was 14, the largest total number named by one child was 34. Several of the children would call successive pictures the same thing, for example "marbles" or "beads." The older children were interested in who made the pictures, asking about them. One boy jokingly named the man incorrectly, calling him a dog and the legs his *two* tails.

Pearson's formula was used to compute the correlations by the method of rank differences. The coefficients are given in table 2.

The drawings of children appear to have greater significance for other children than have the compositions of modern artists. There is also a relatively large degree of universality in the names given by children to the spontaneous productions of other children of approximately the same age and environmental status.

ROBERTA WHITE,
BUFORD JOHNSON.

TABLE 1

	PICTURE NUMBER									
	1	2	3	4	5	6	7	8	9	10
(a) Children naming one or more pictures correctly	10	0	17	0	12	19	23	5	19	21
(b) Objects or parts of pictures correctly named	11	0	39	0	12	20	32	7	21	37
(c) Total objects named	30	24	54	25	50	39	58	33	42	58
(d) Different objects named	20	21	21	14	29	19	32	20	19	29

TABLE 2

	SCORES		
	C.A.	M.A.	I.Q.
Pictures correct (a)	0.78 ± 0.06	0.77 ± 0.06	0.22 ± 0.11
Objects correct (b)	0.75 ± 0.06		
Objects named (c)	0.64 ± 0.08	0.74 ± 0.06	0.40 ± 0.11

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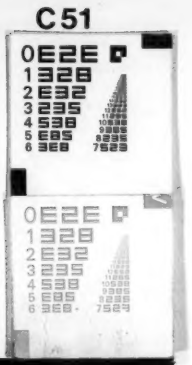
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